The “pattern effect” in CERES data

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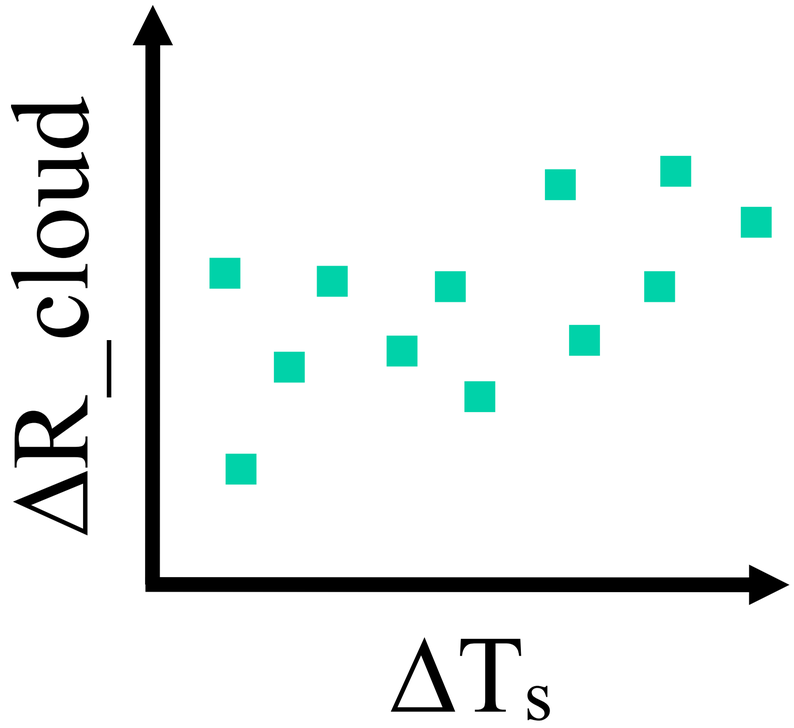

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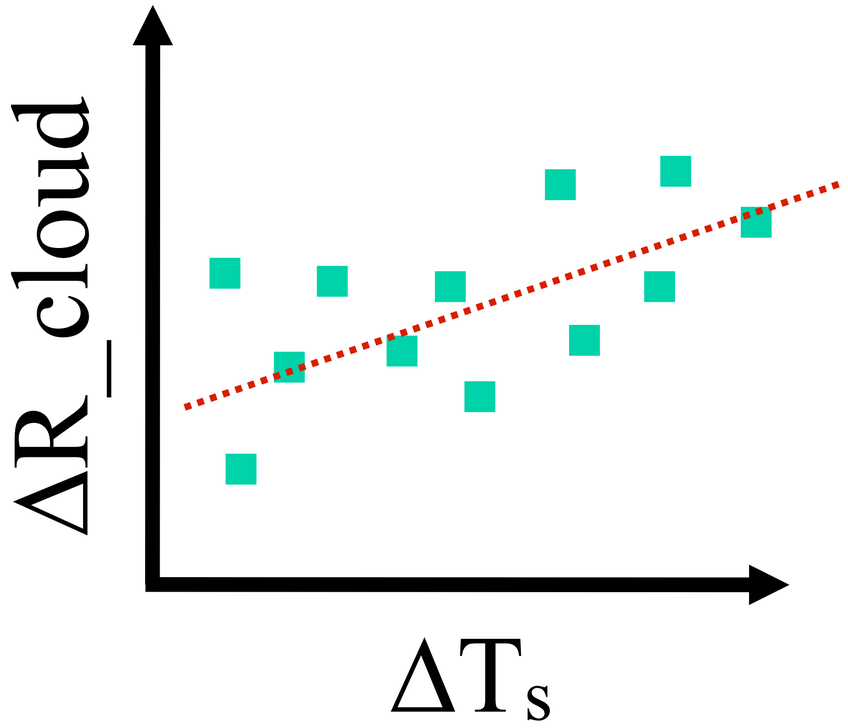

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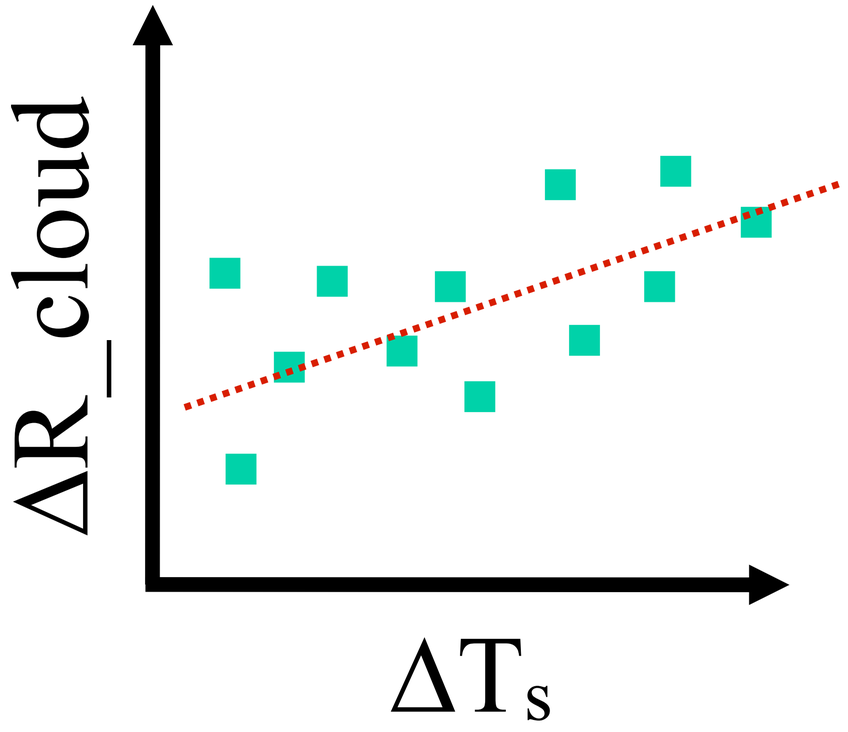
- slope = cloud feedback
- ΔR_cloud can be at grid point, zonal avg. global avg.



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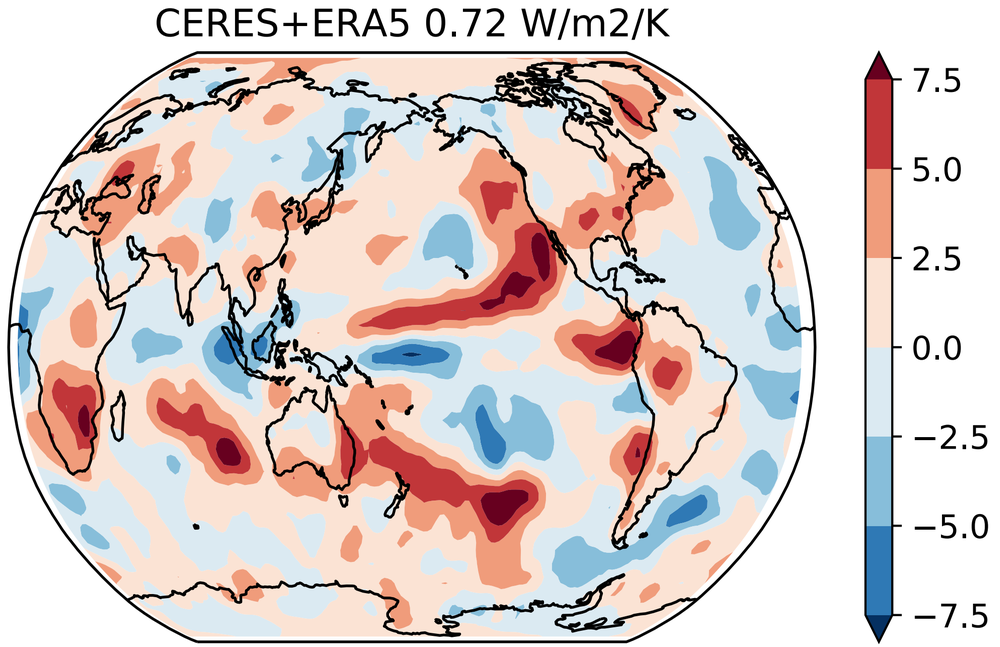

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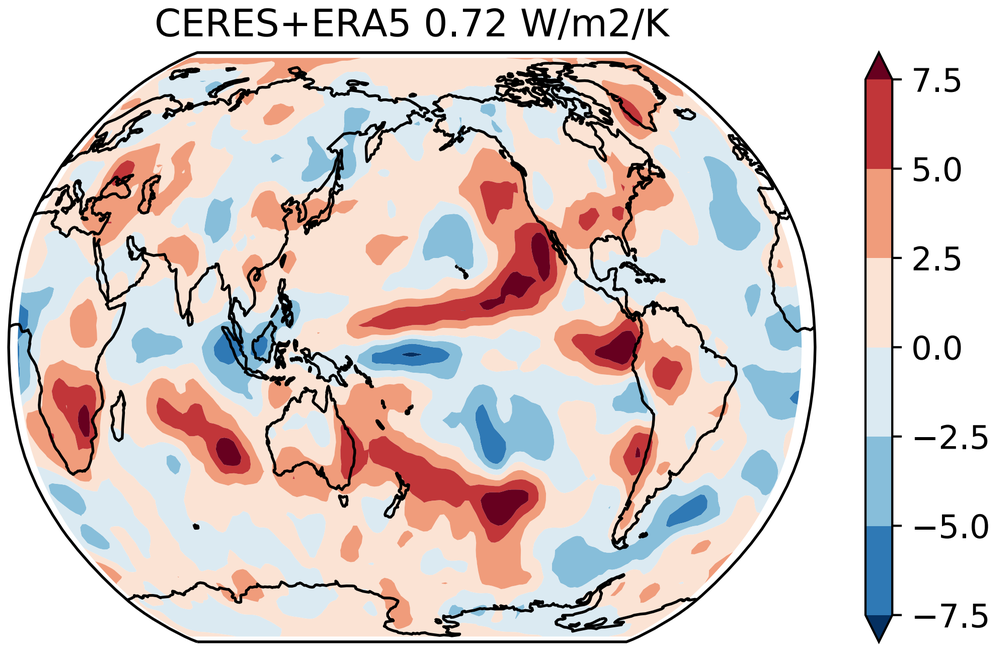

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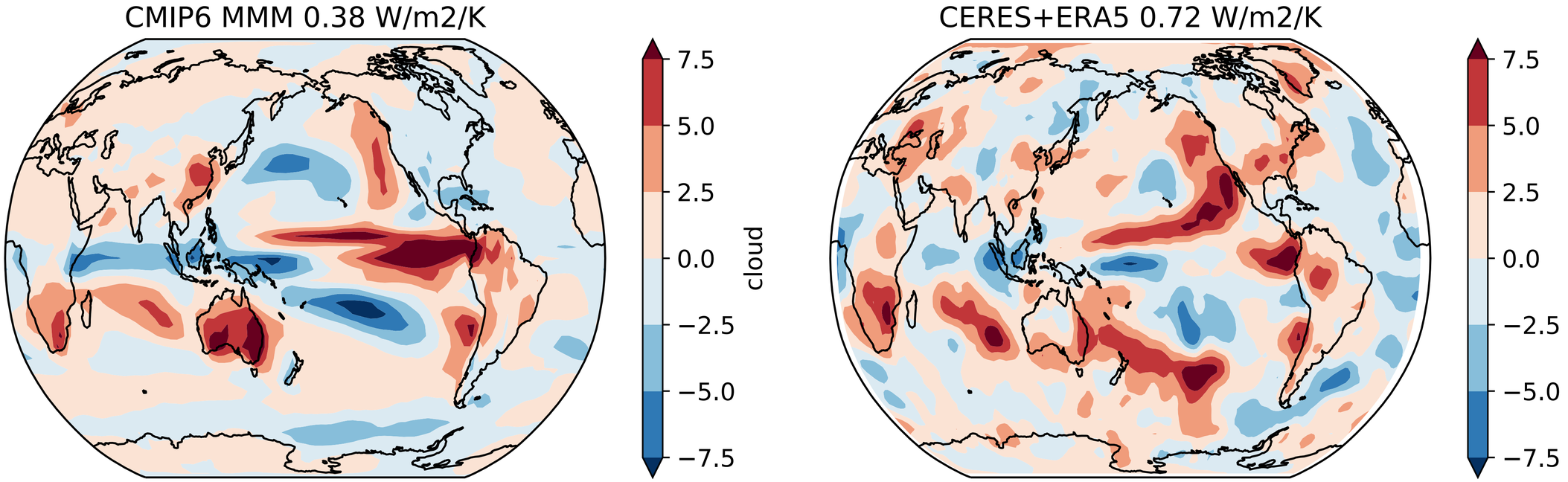

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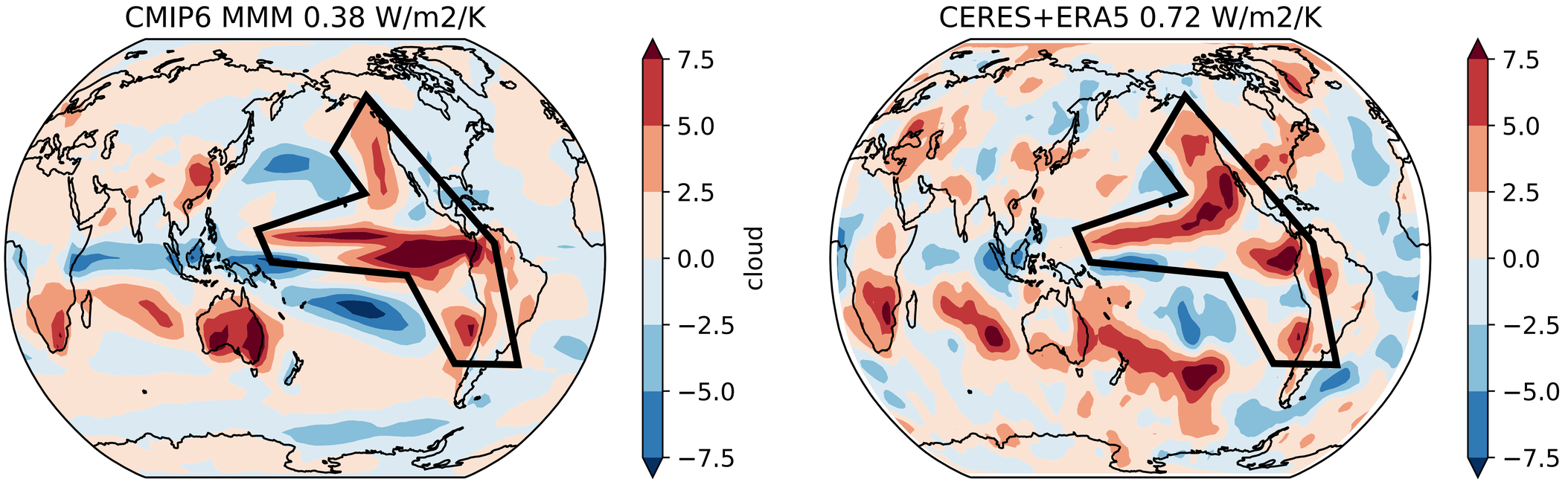

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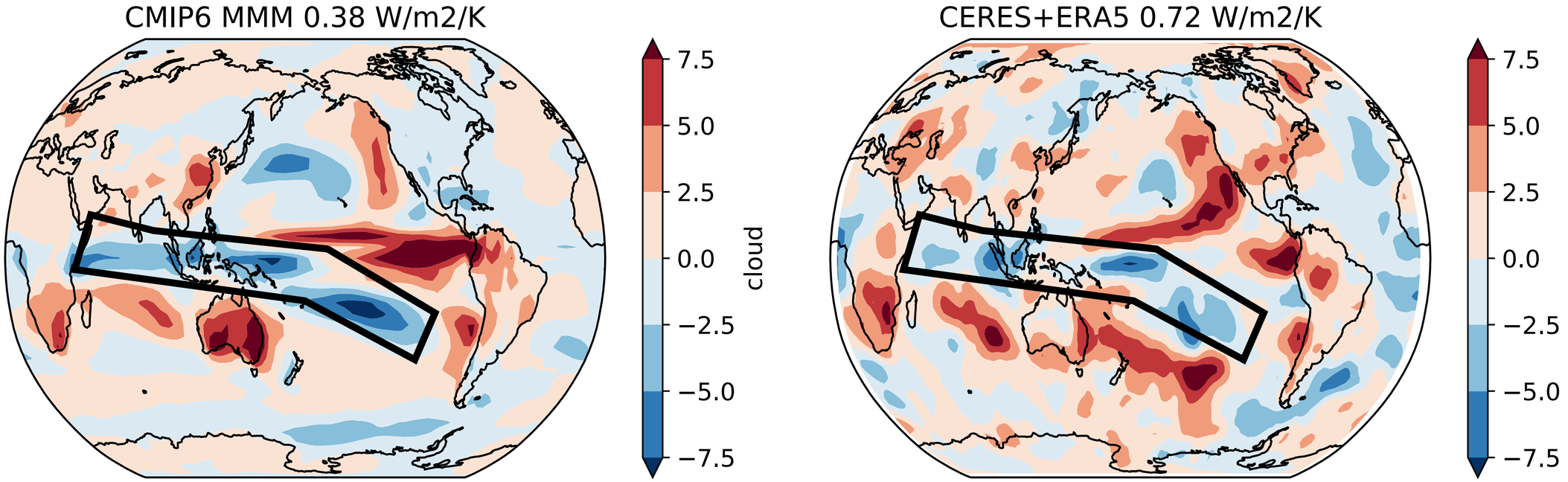

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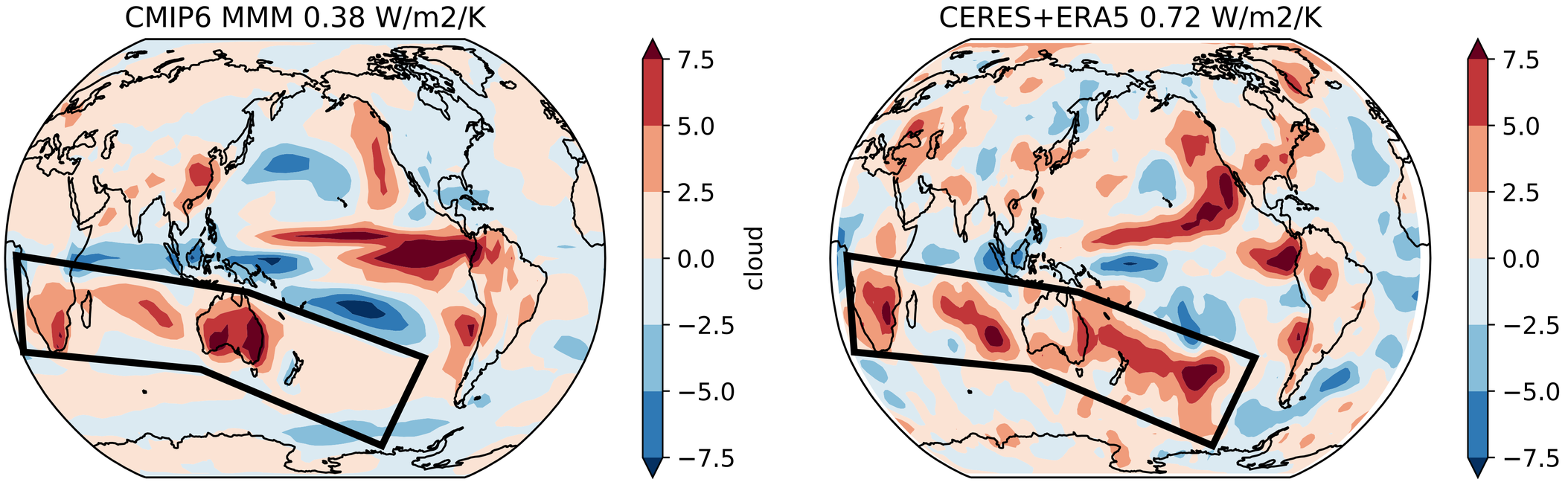

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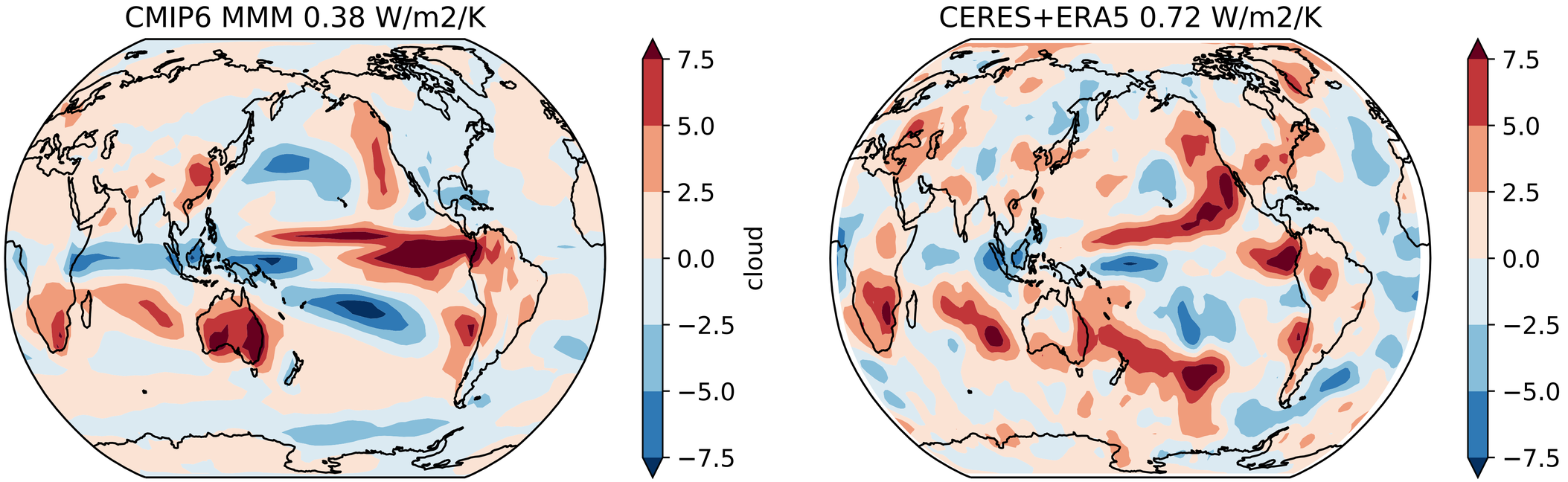

models are doing a **good job** simulating the details of the cloud feedback in the CERES data

“pattern effect”

- models suggest cloud feedback varies due to internal variability

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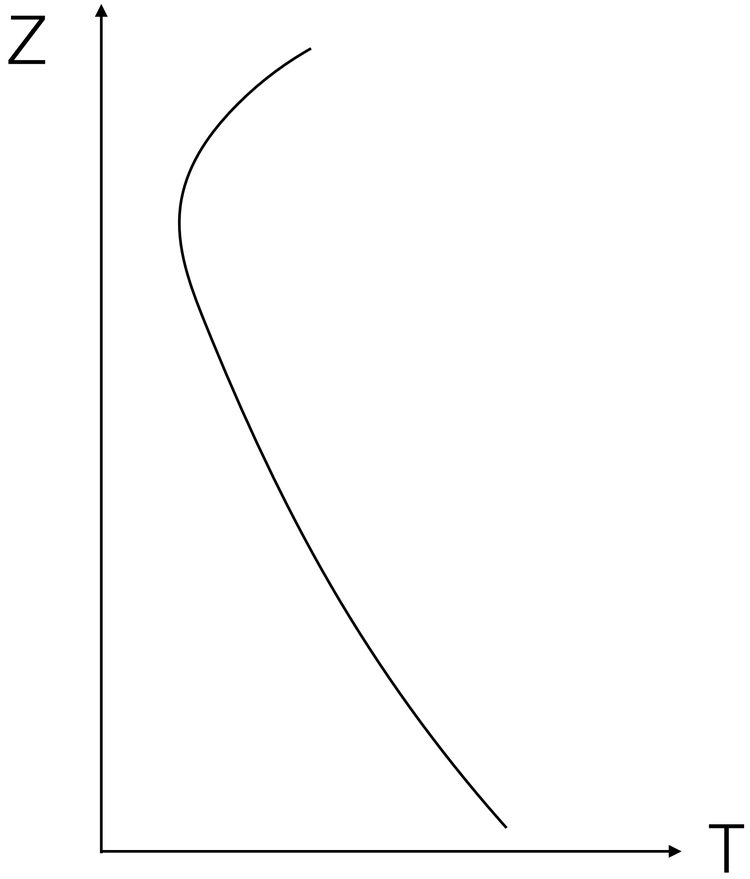
“pattern effect”

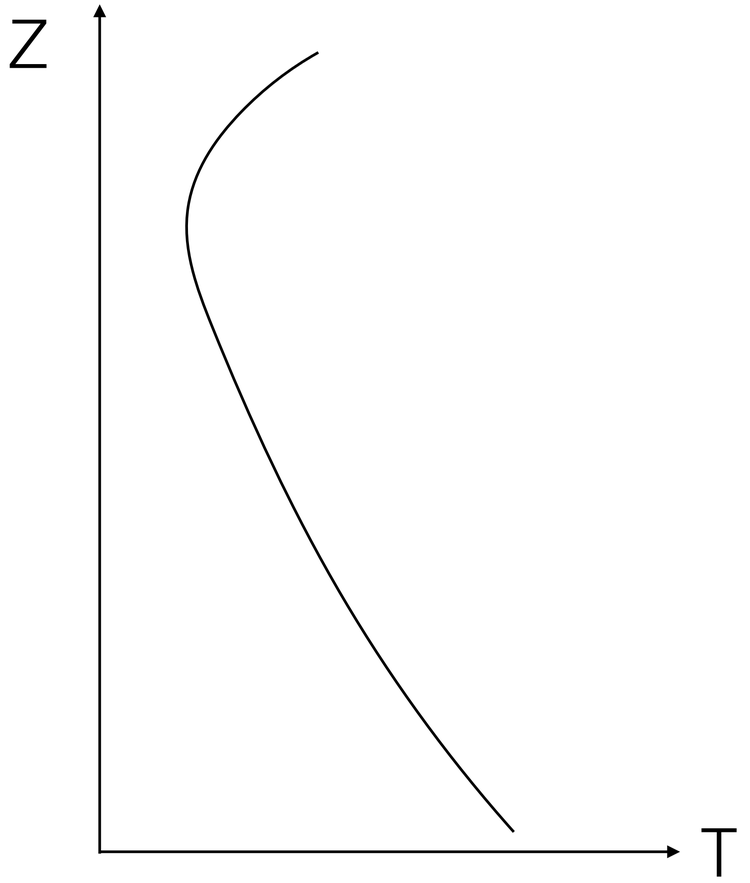
- models suggest cloud feedback varies due to internal variability
- the same amount of warming, but distributed differently, can lead to different cloud feedback
- underpredict ECS
- CERES spring meeting talk: underpredict future warming
- can we use CERES data to verify that changes in surface pattern change the cloud feedback?

West Pacific

East Pacific

Zhou et al..: Analyzing the dependence of global cloud feedback on the spatial pattern of sea surface temperature change with a Green's function approach, Journal of Advances in Modeling Earth Systems, 9, 2174-2189, 10.1002/2017MS001096, 2017.





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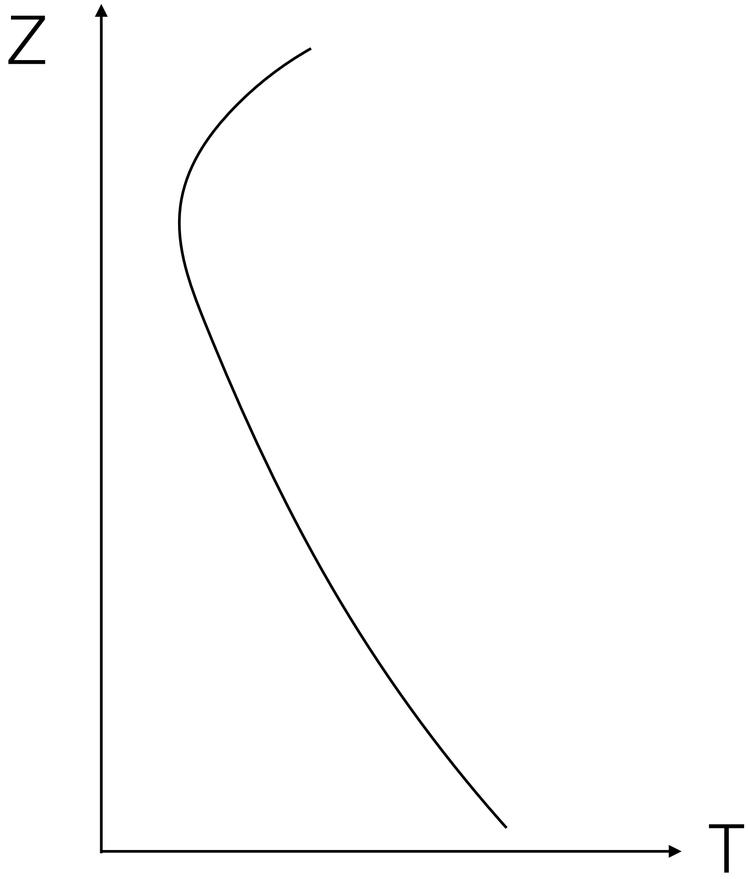

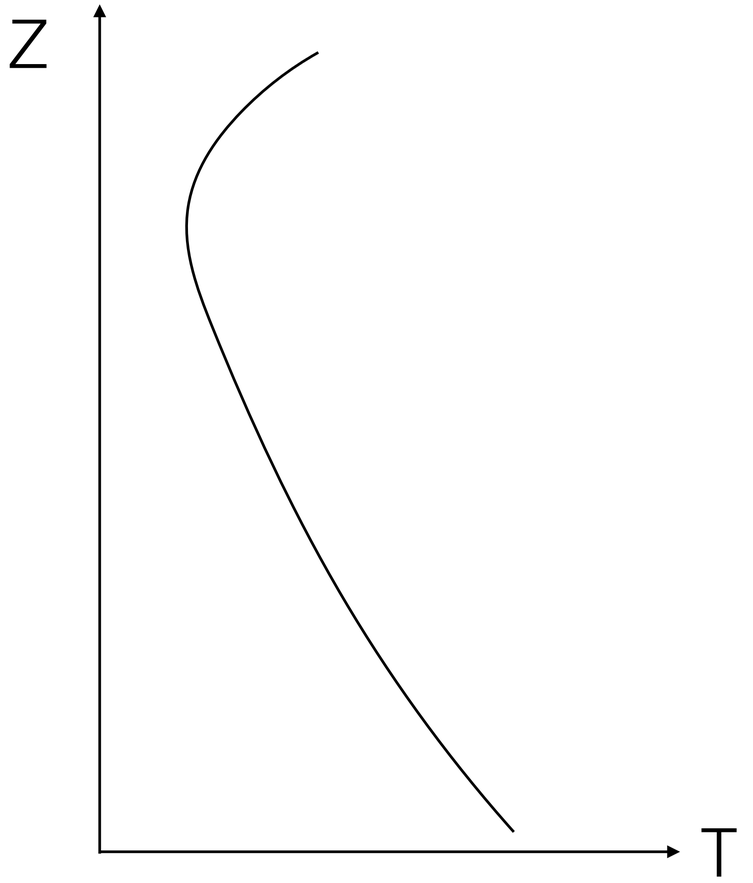

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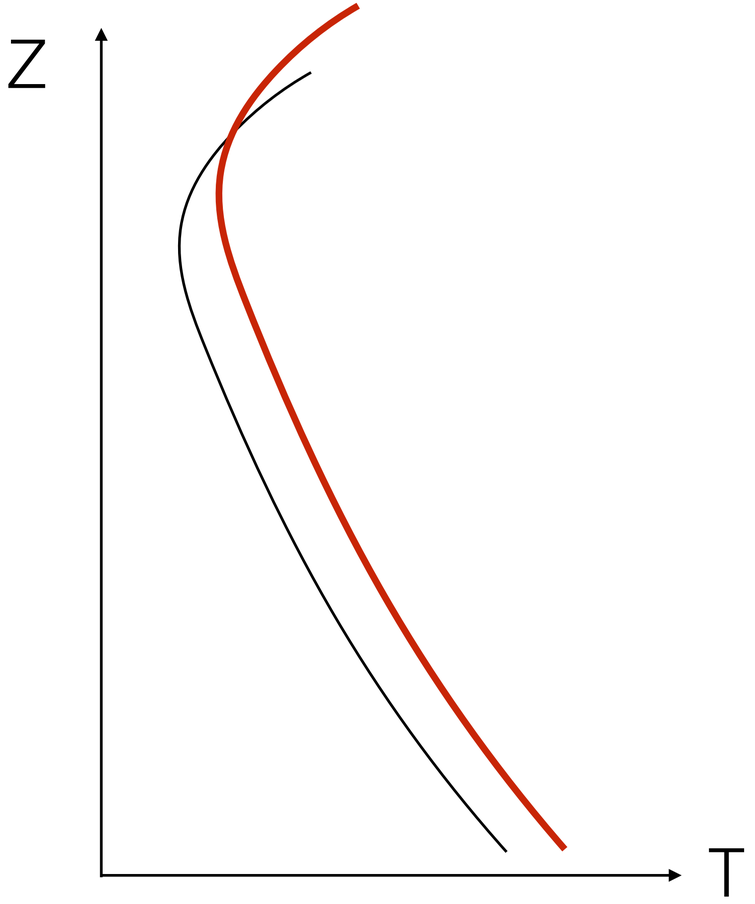

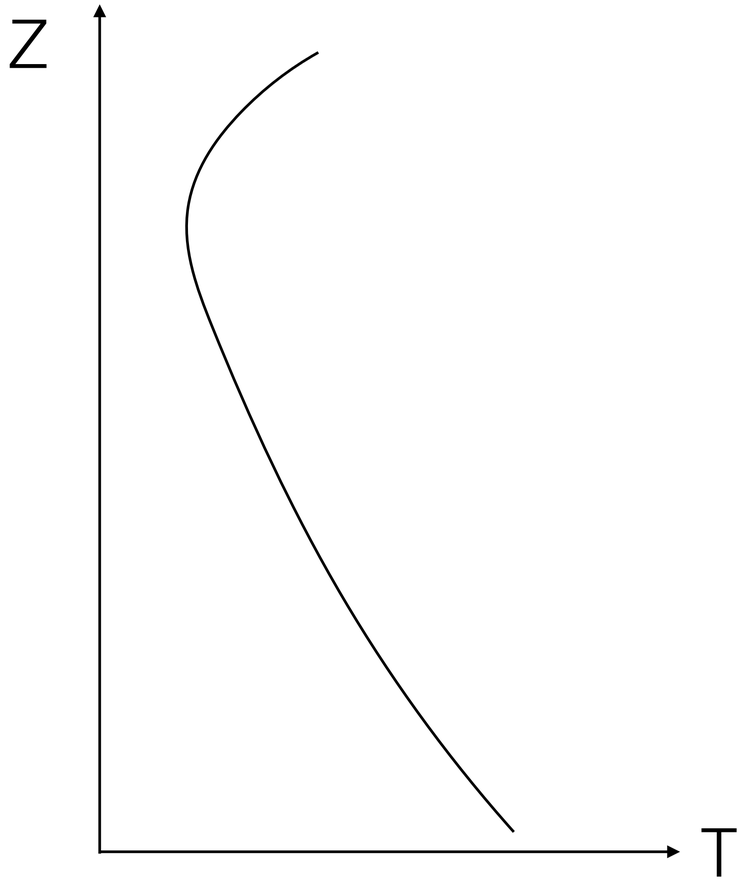

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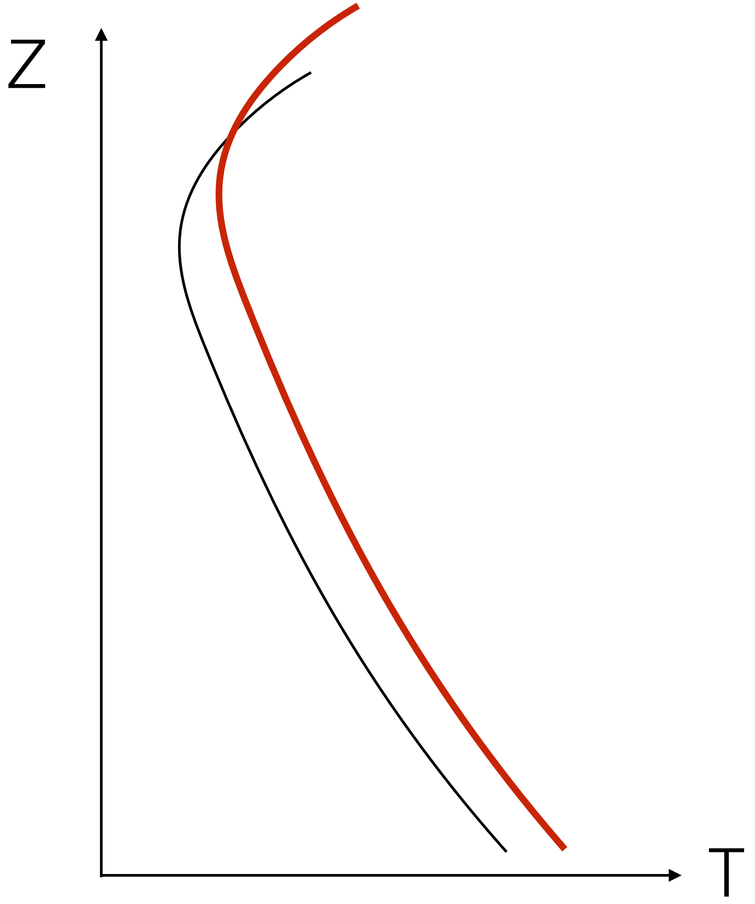

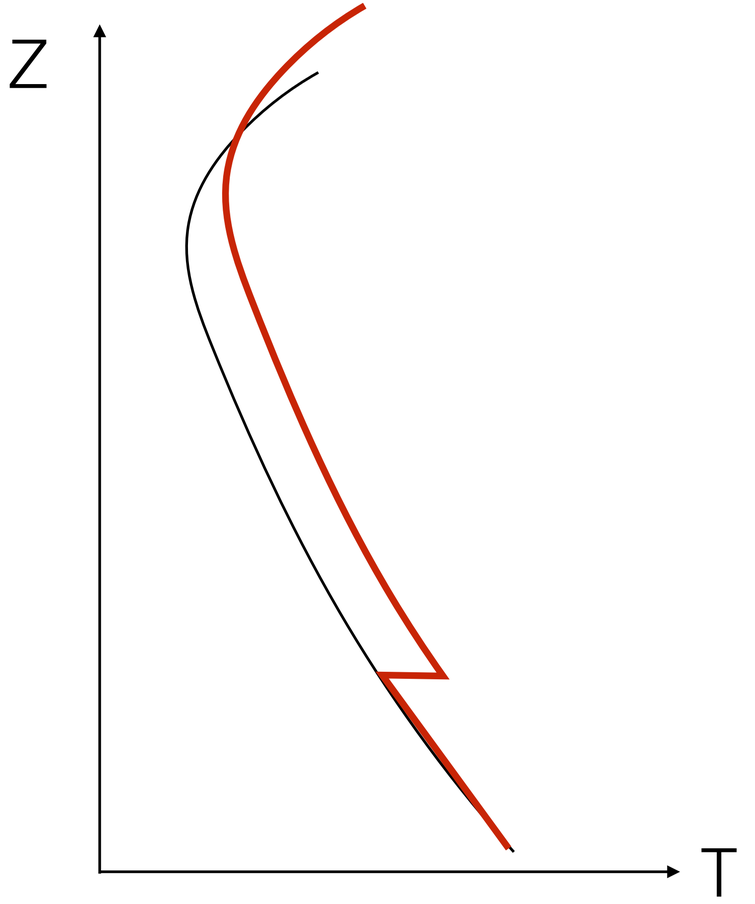

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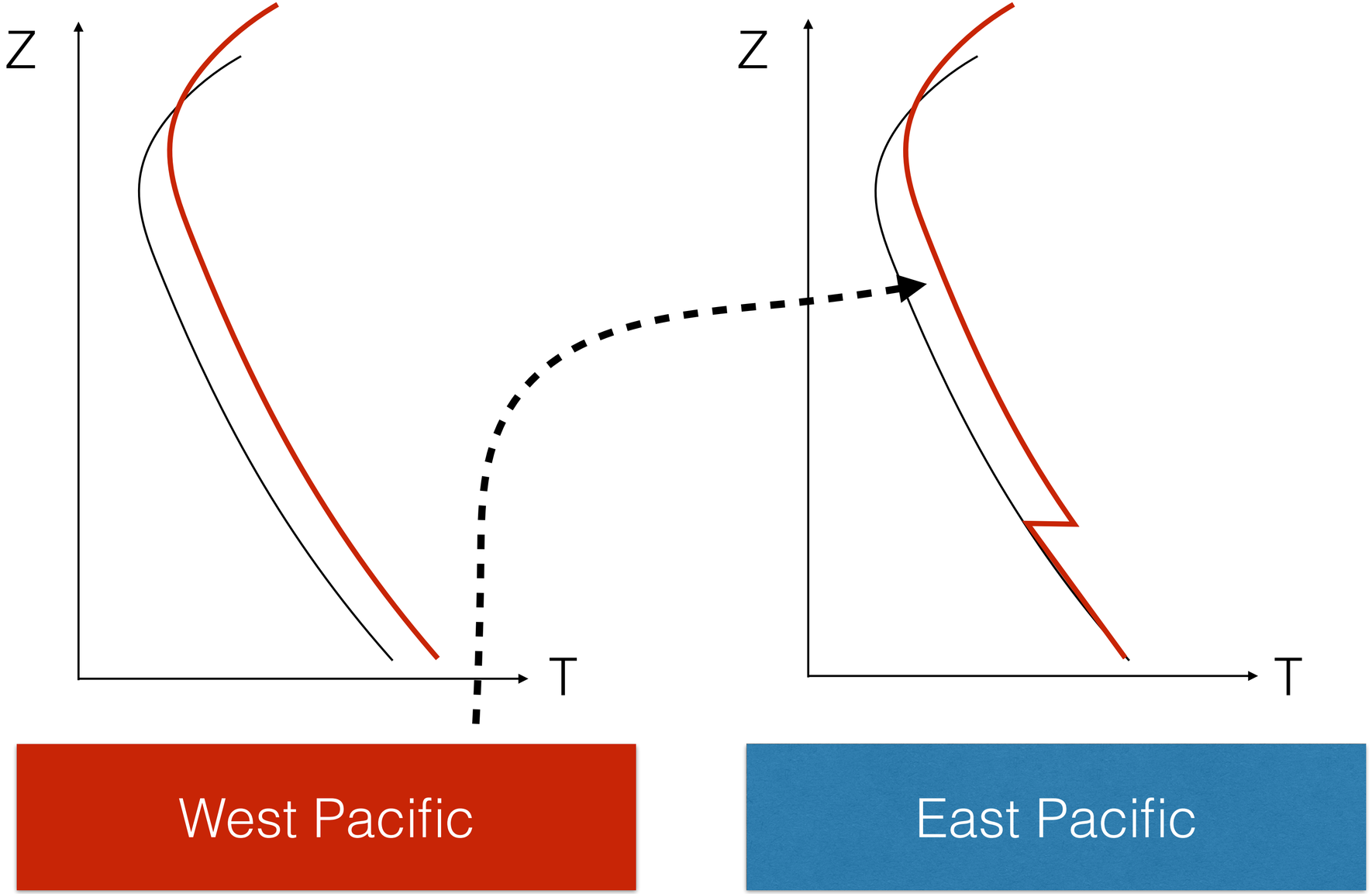

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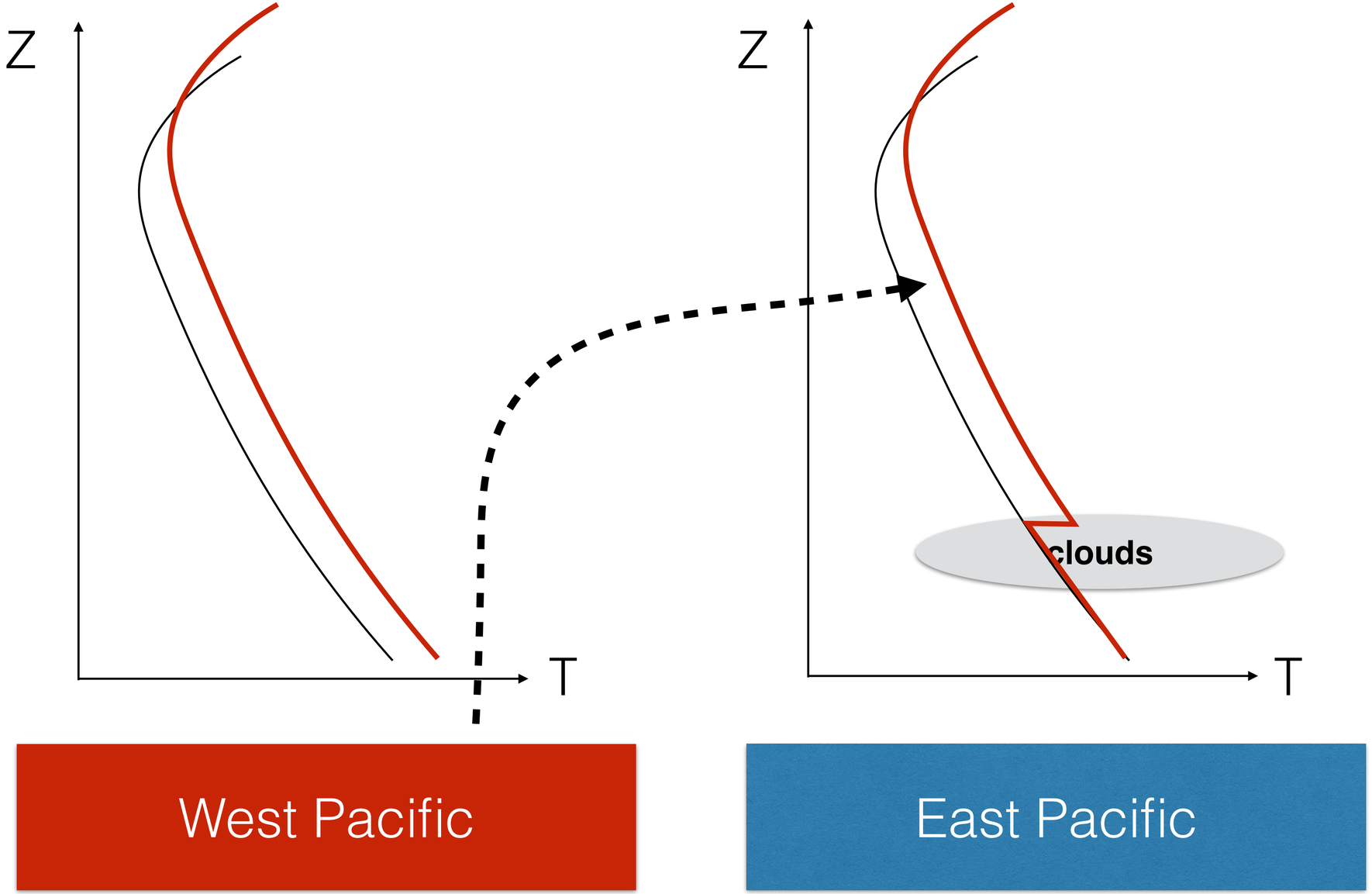

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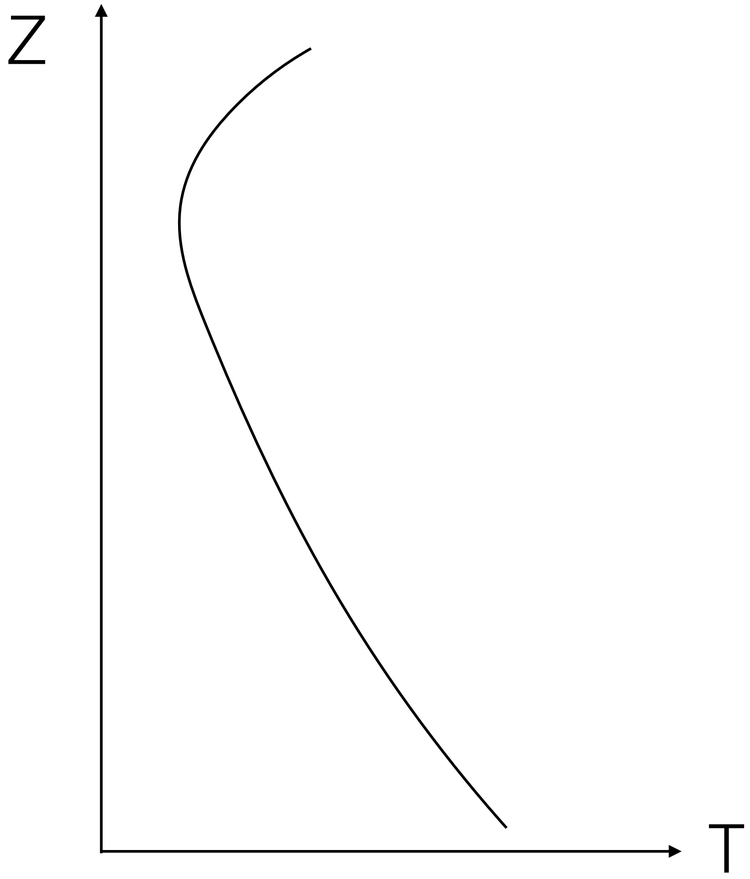

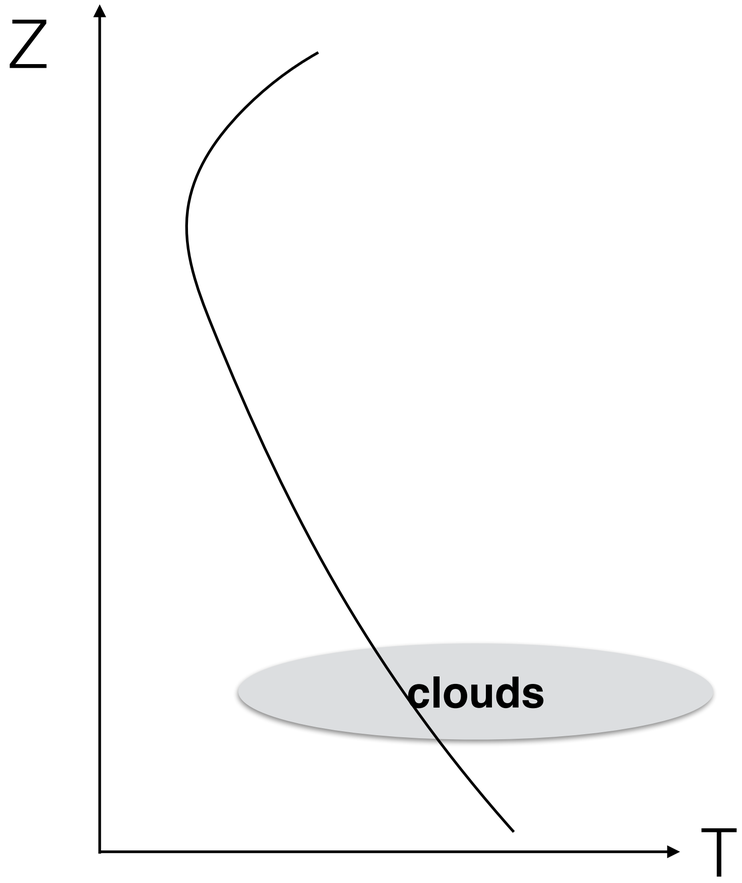

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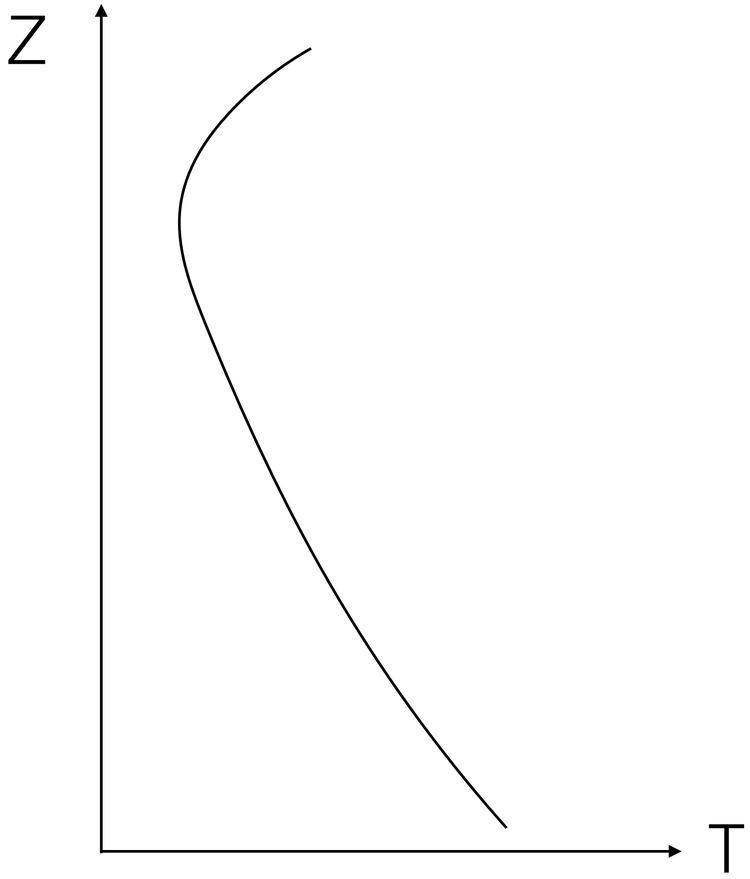

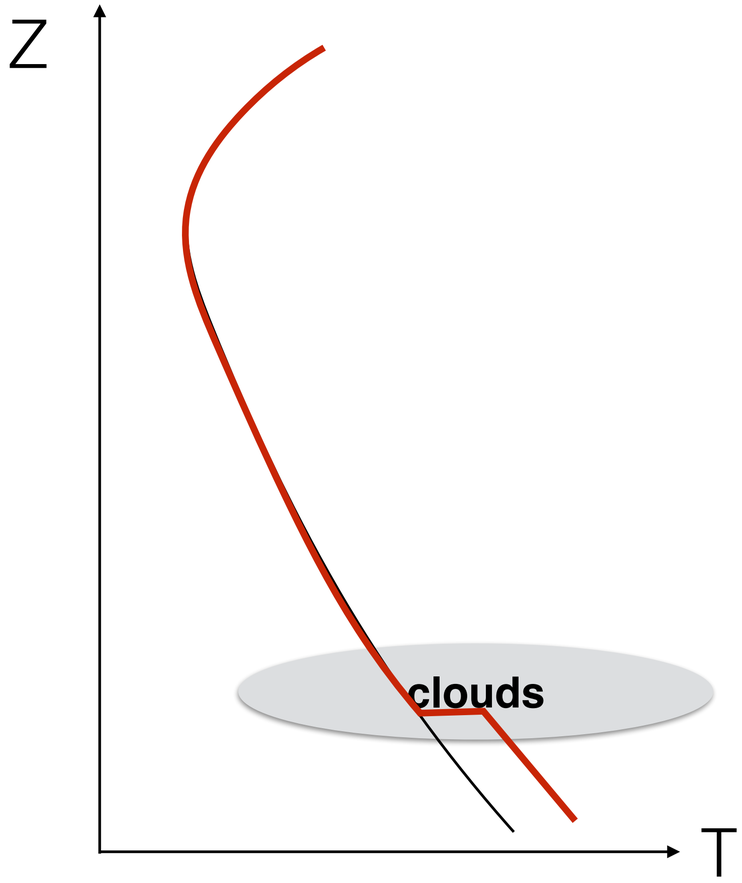

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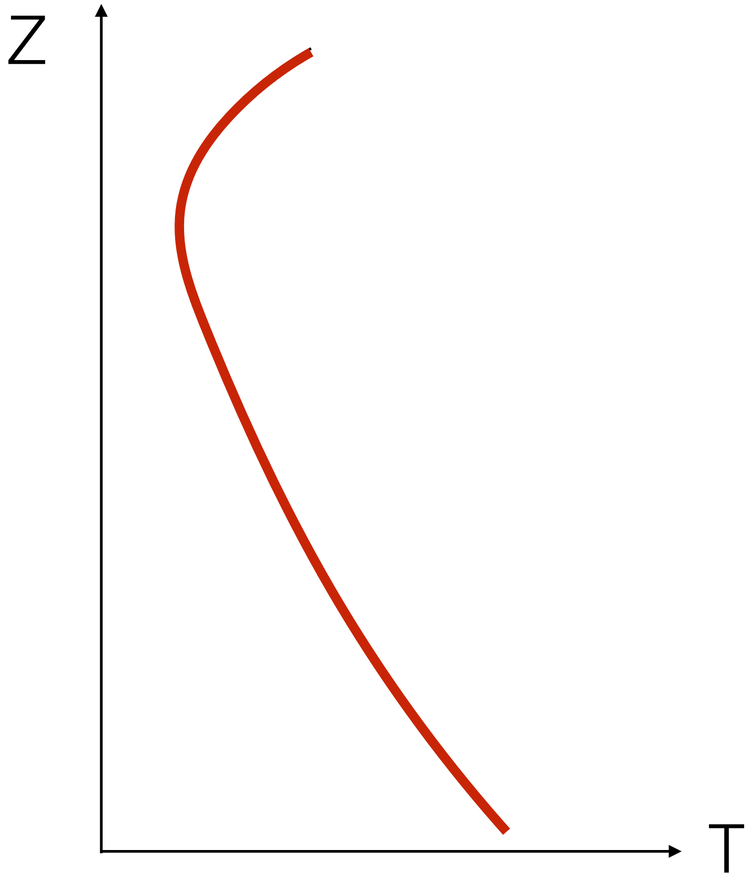

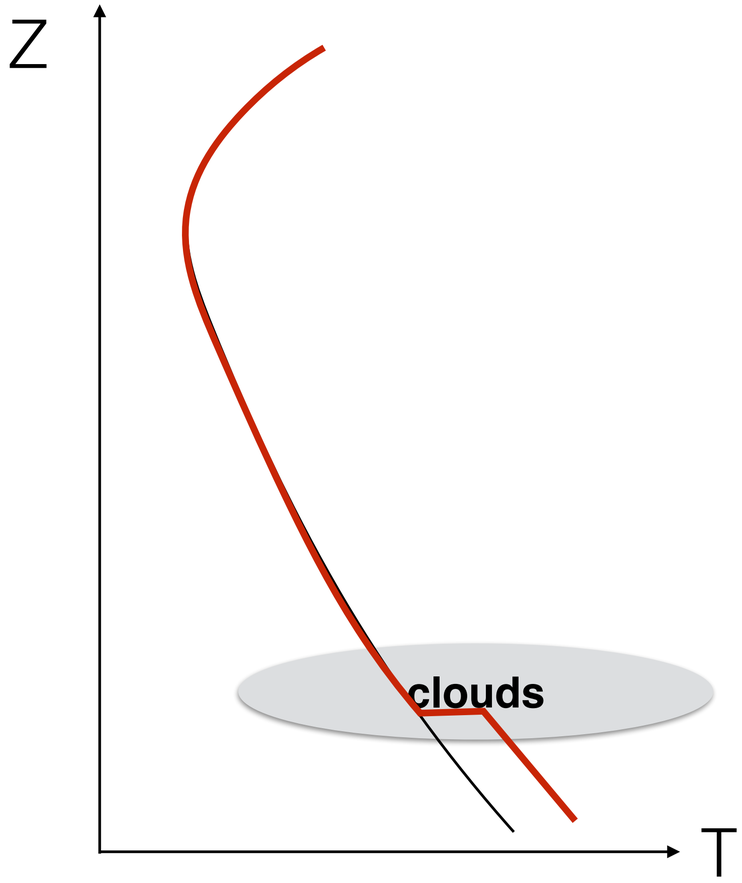

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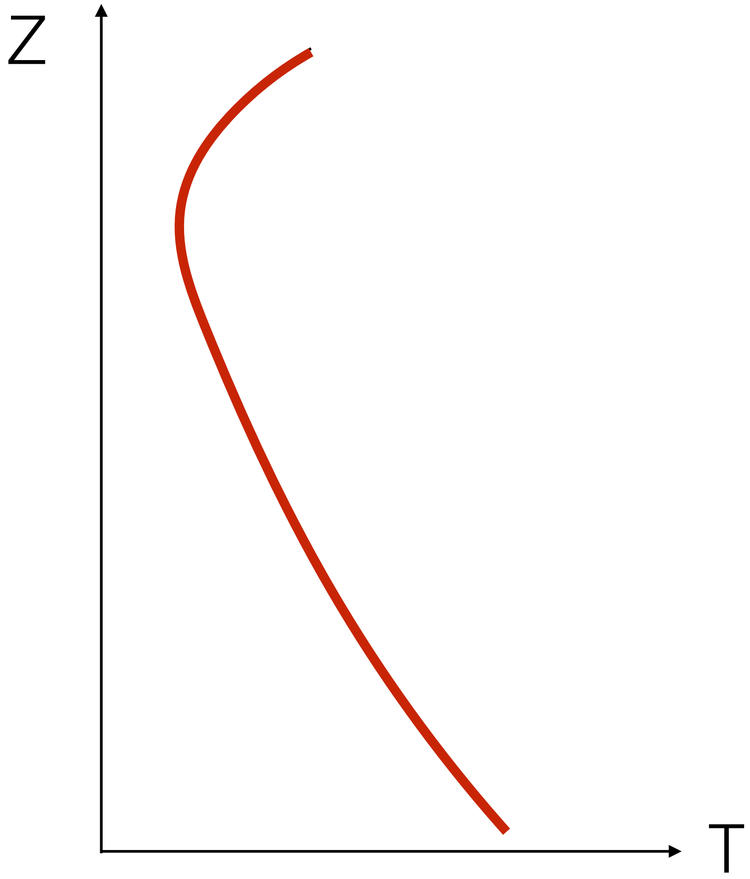

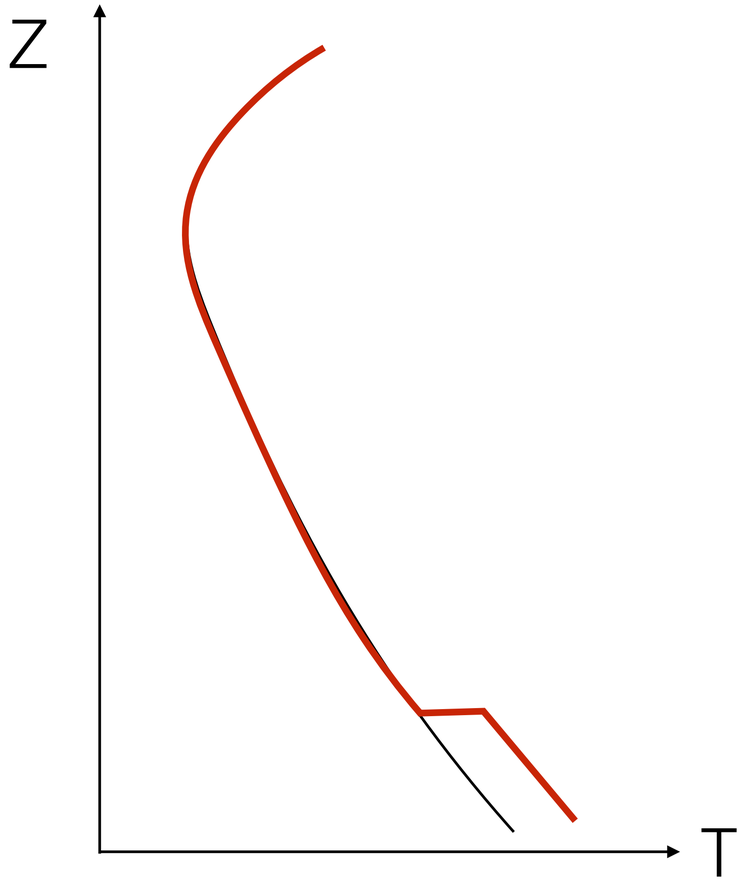

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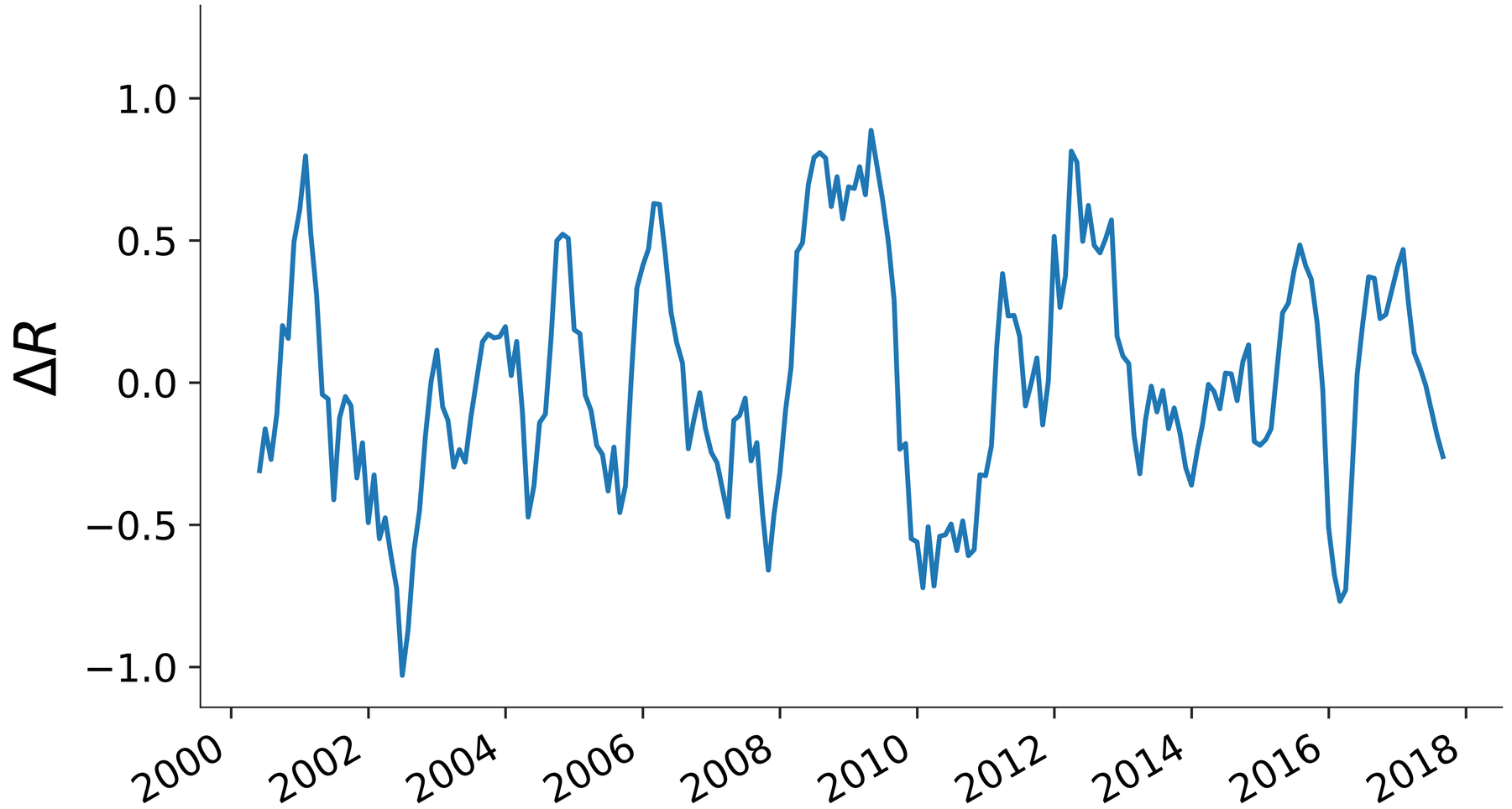
top-of-atmosphere (TOA) net flux



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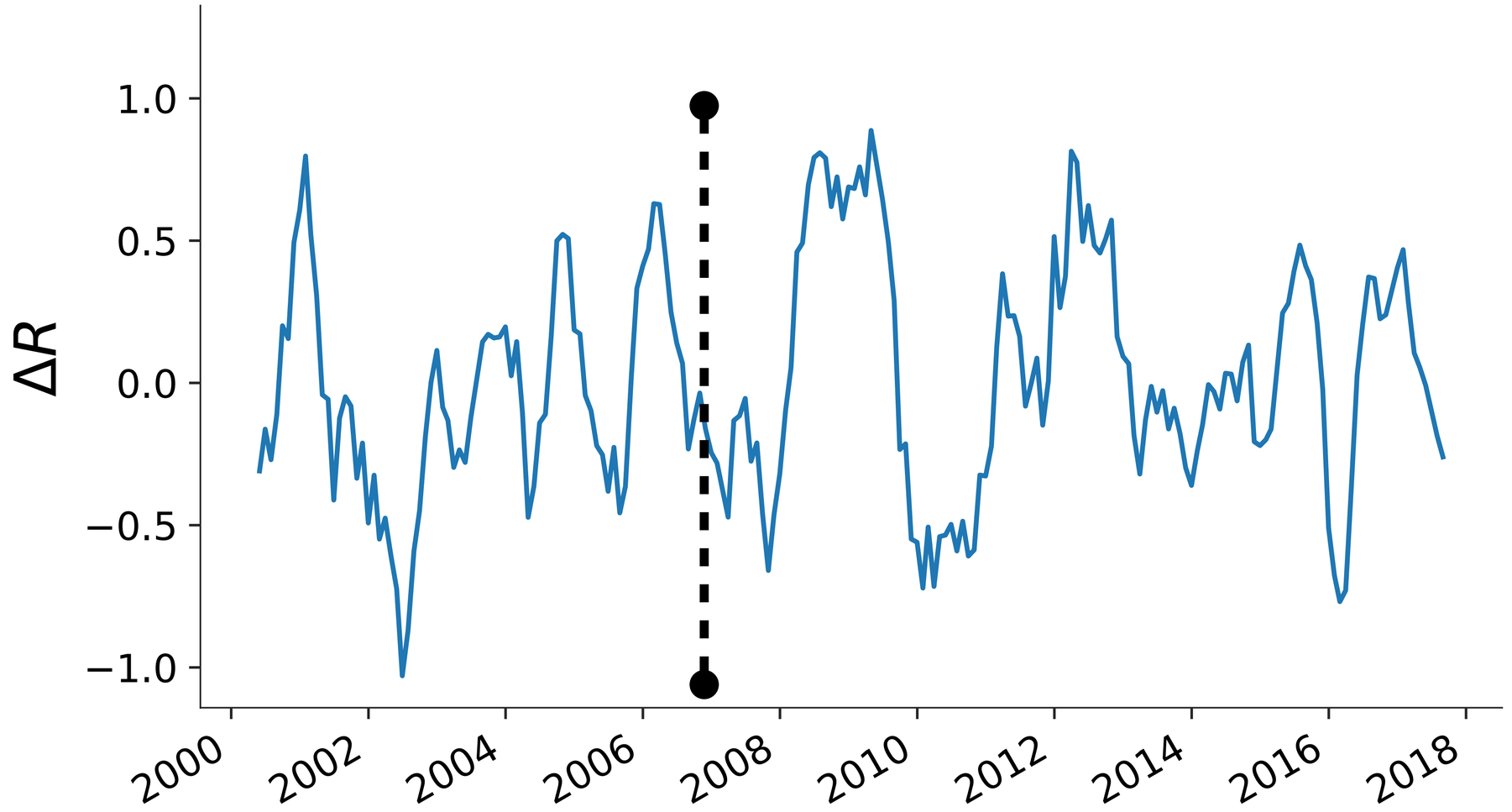

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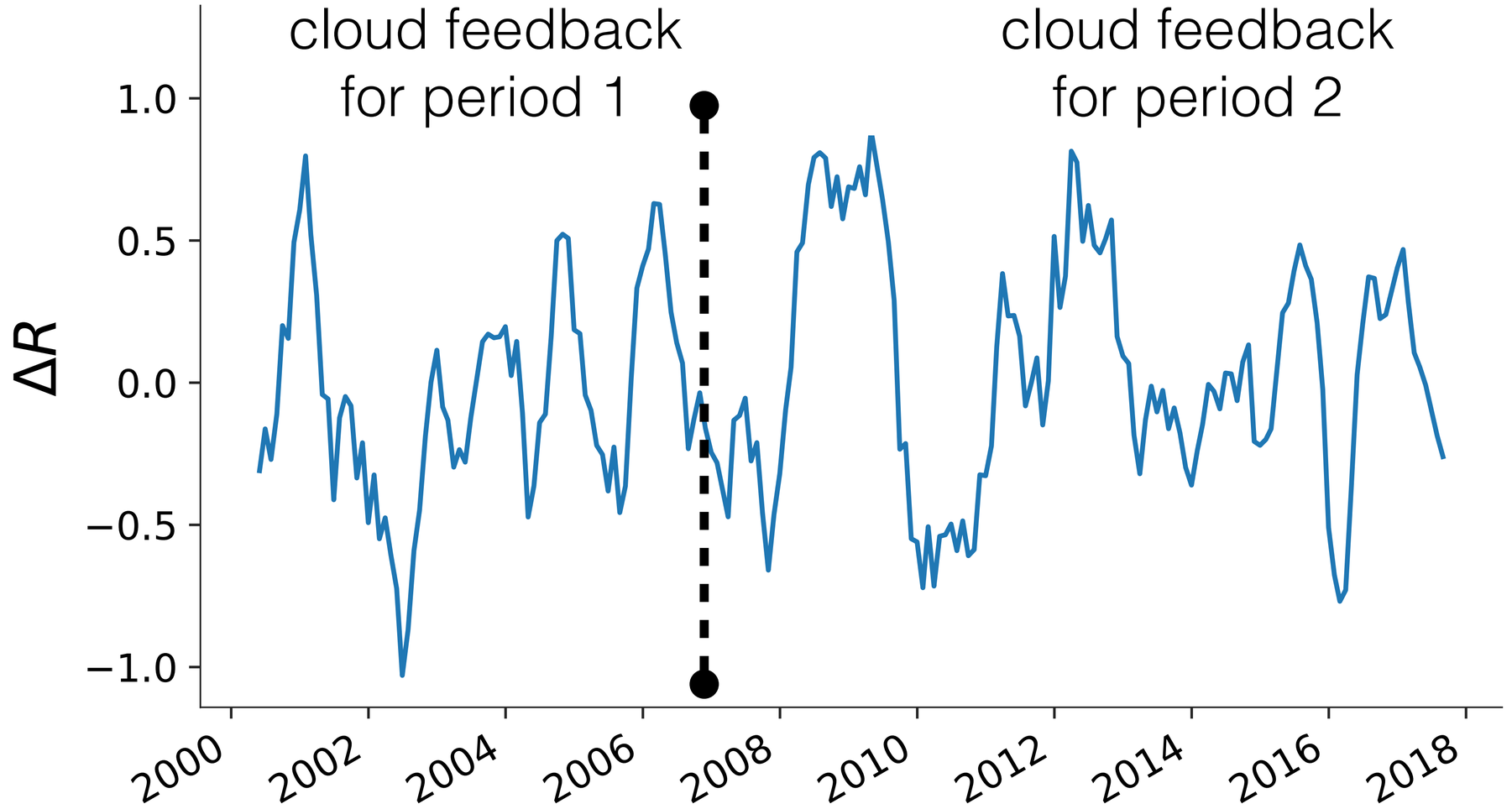

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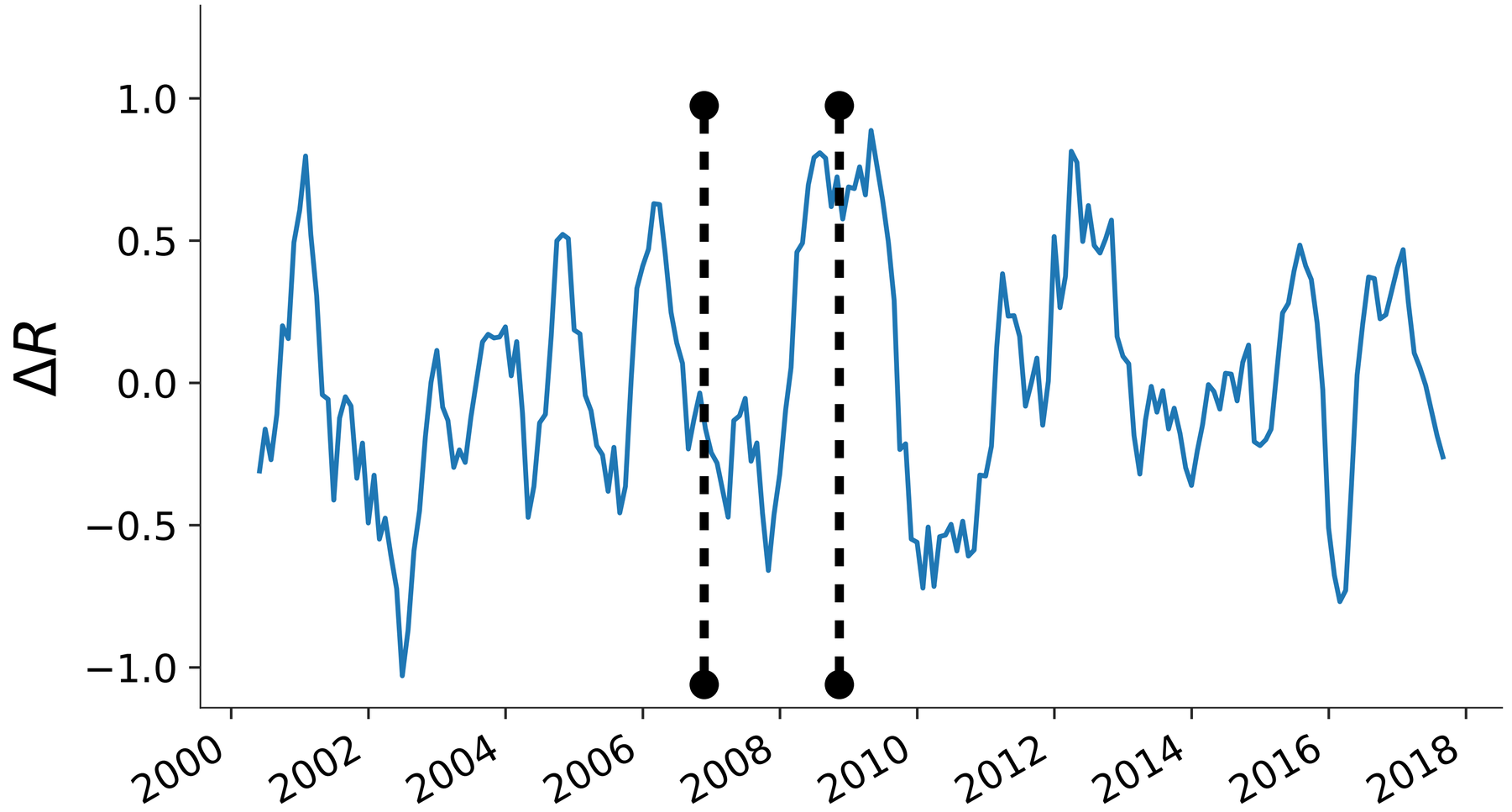

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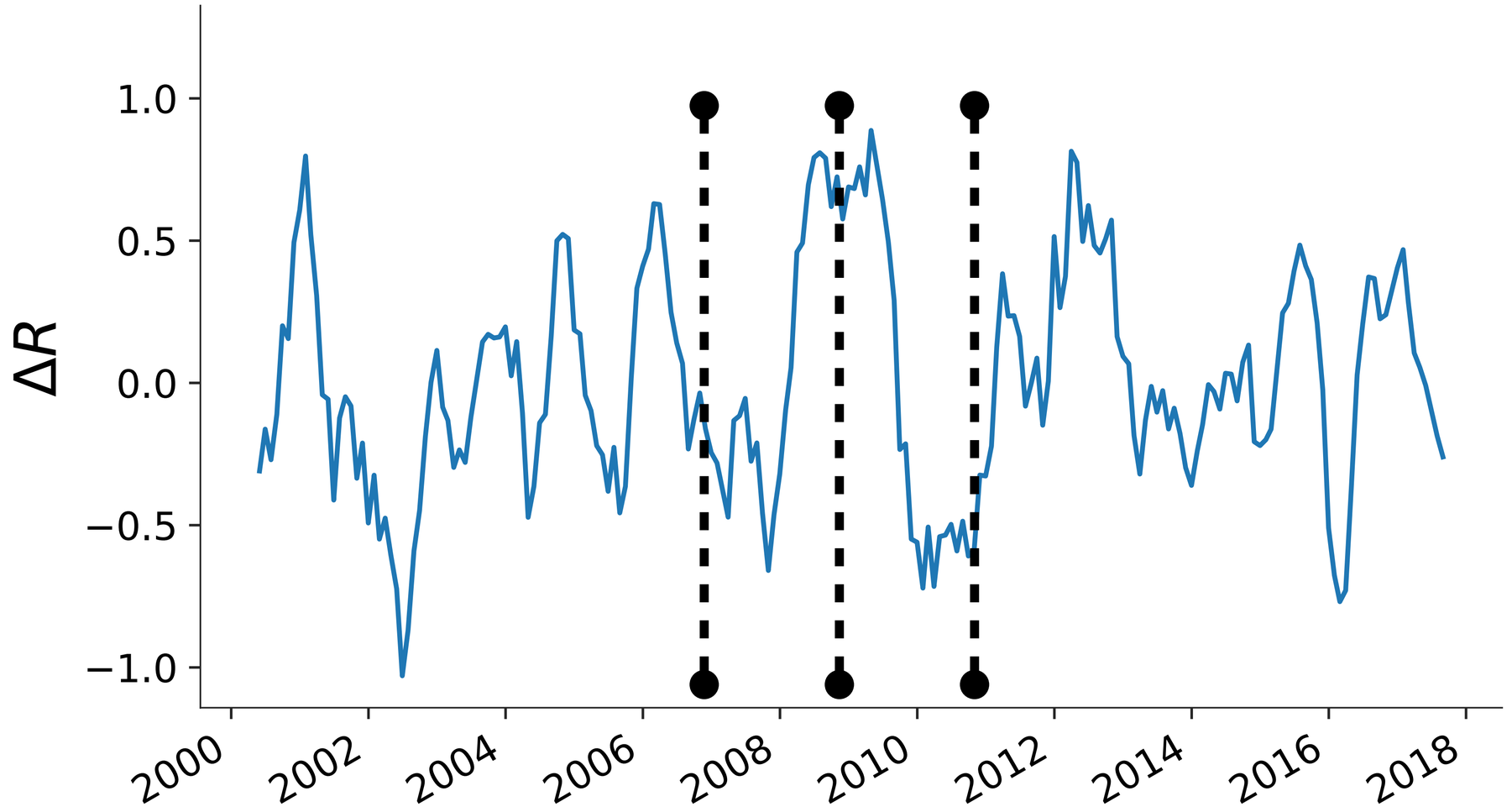

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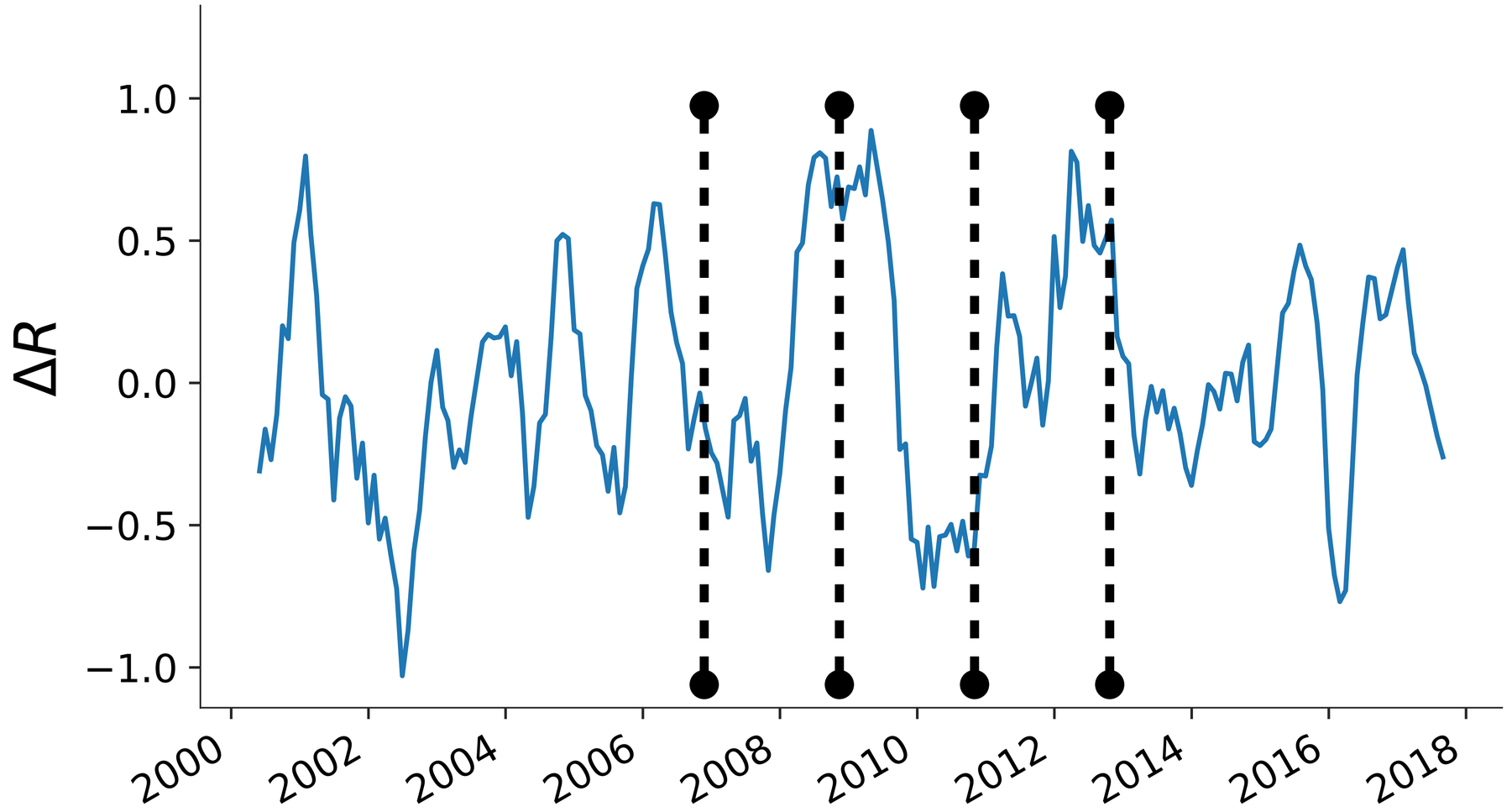

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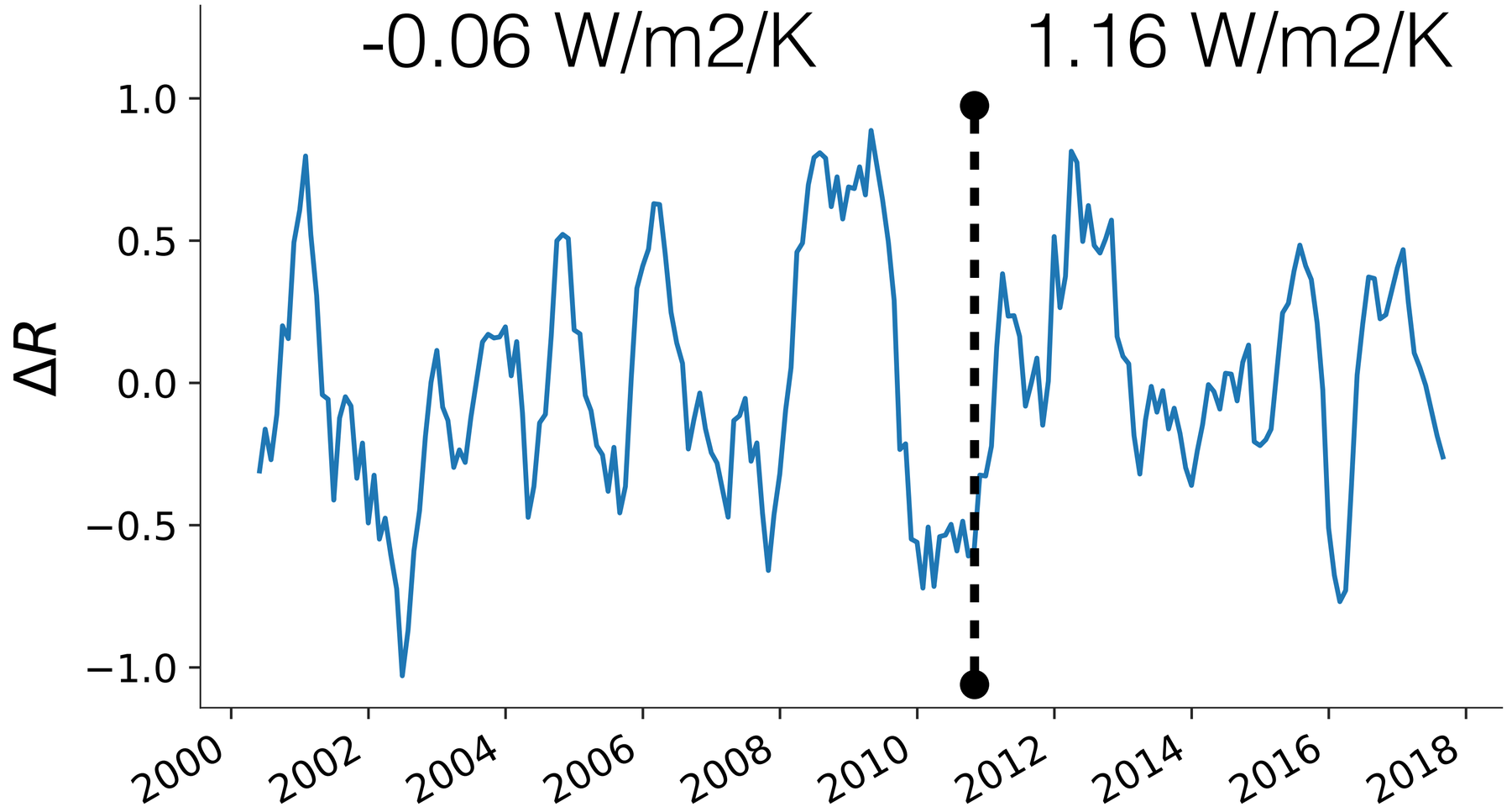

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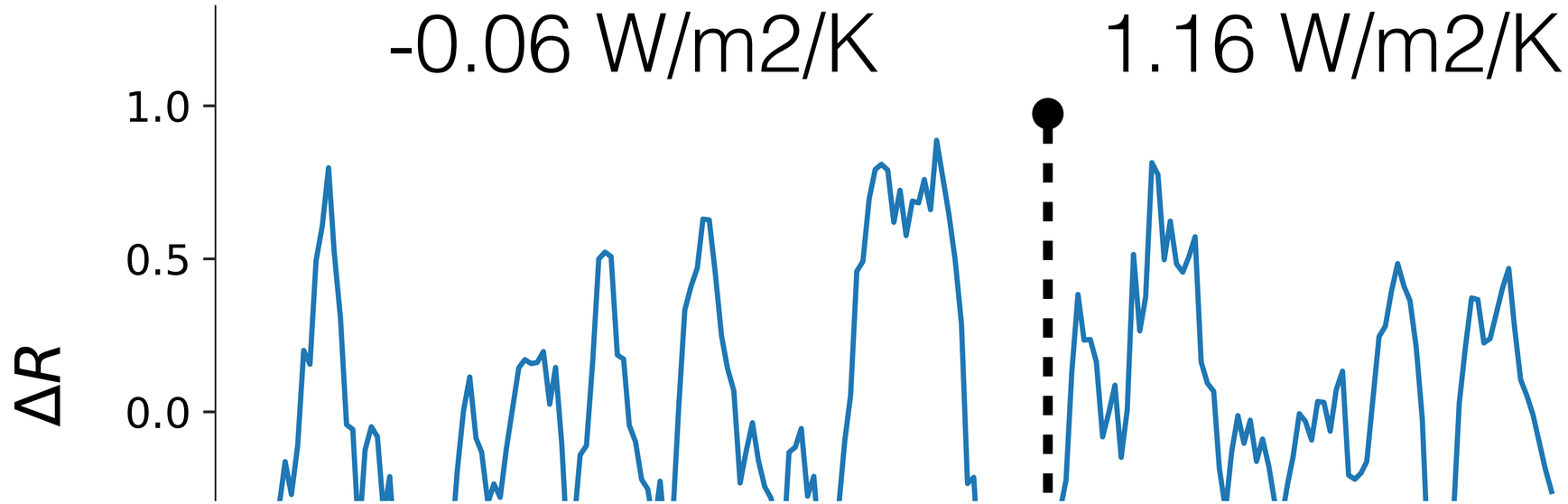

Geophysical Research Letters

RESEARCH LETTER
10.1029/2019GL086705

Key Points:

- There is good agreement between radiation budget variations observed by CERES and simulated by seven state-of-the-art climate models
- The relationship between global mean net TOA radiation and surface temperature is sensitive to changes in regions dominated by low clouds
- Most models underestimate

New Generation of Climate Models Track Recent Unprecedented Changes in Earth's Radiation Budget Observed by CERES

Norman G. Loeb[1], Hailan Wang[2], Richard P. Allan[3], Timothy Andrews[4], Kyle Armour[5], Jason N. S. Cole[6], Jean-Louis Dufresne[7], Piers Forster[8], Andrew Gettelman[9], Huan Guo[10], Thorsten Mauritsen[11], Yi Ming[10], David Paynter[10], Cristian Proistosescu[12,13], Malte F. Stuecker[14], Ulrika Willén[15], and Klaus Wyser[15]

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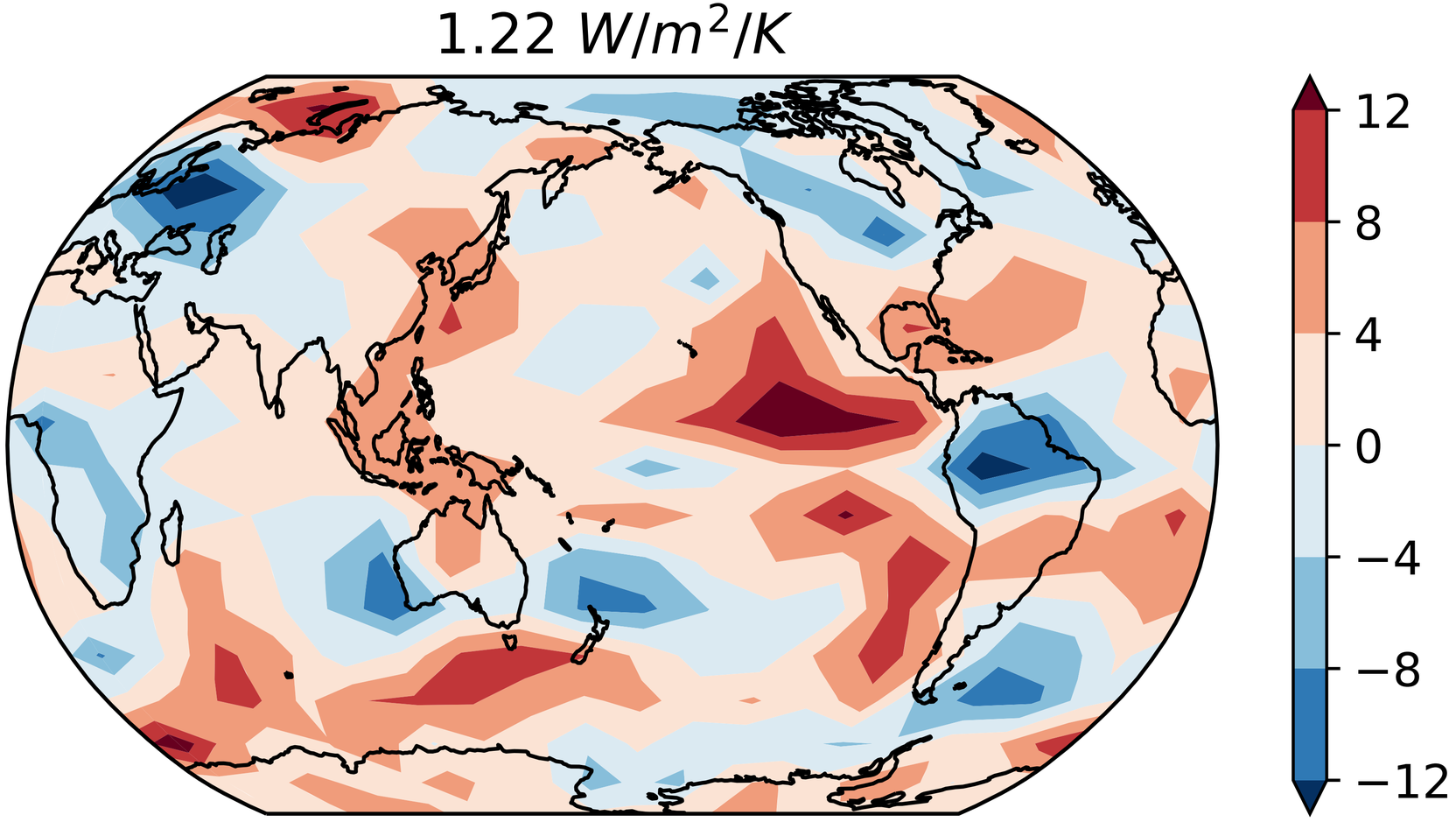
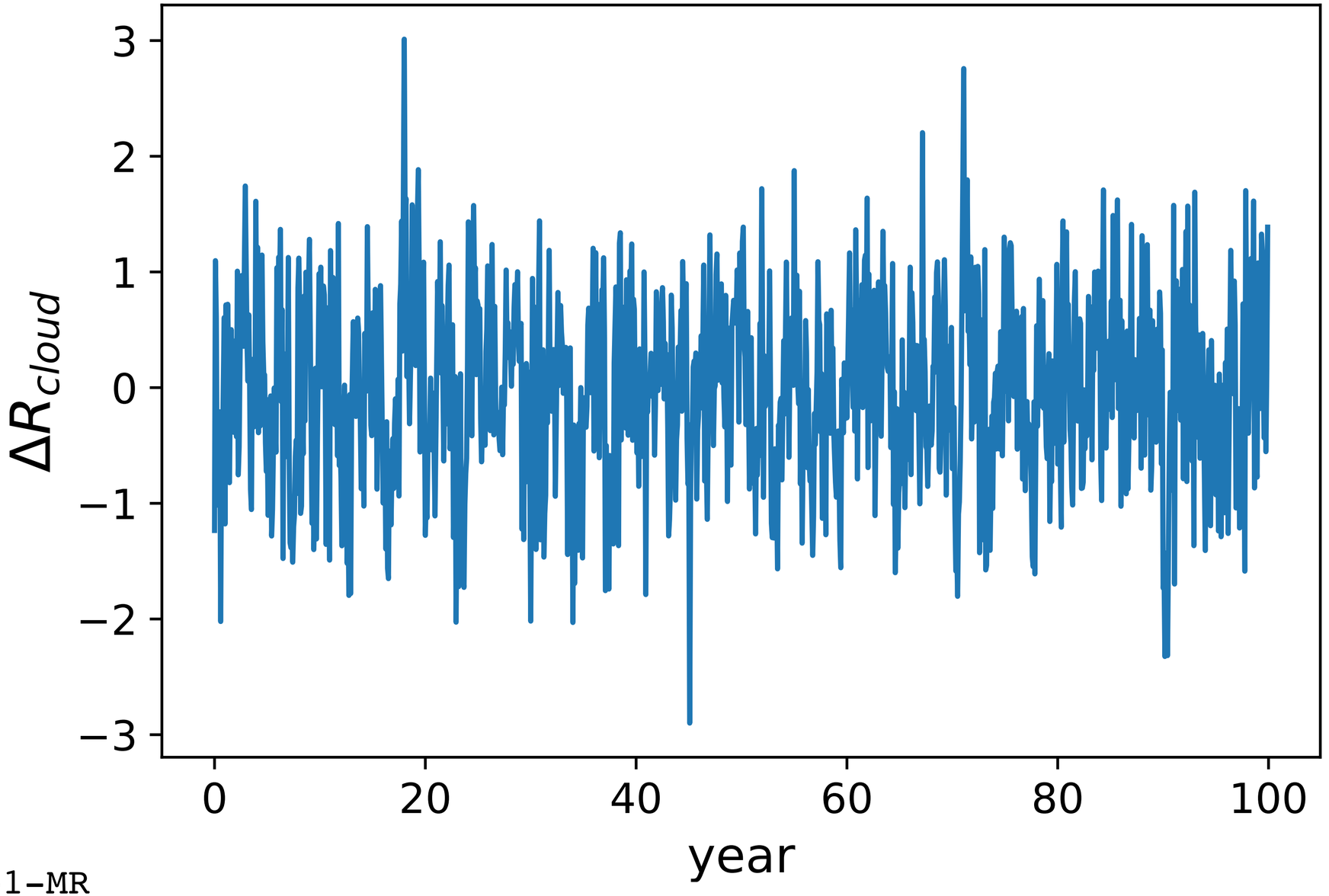


period 2 minus period 1

100 years of a climate model control run



model:
AWI-CM-1-1-MR

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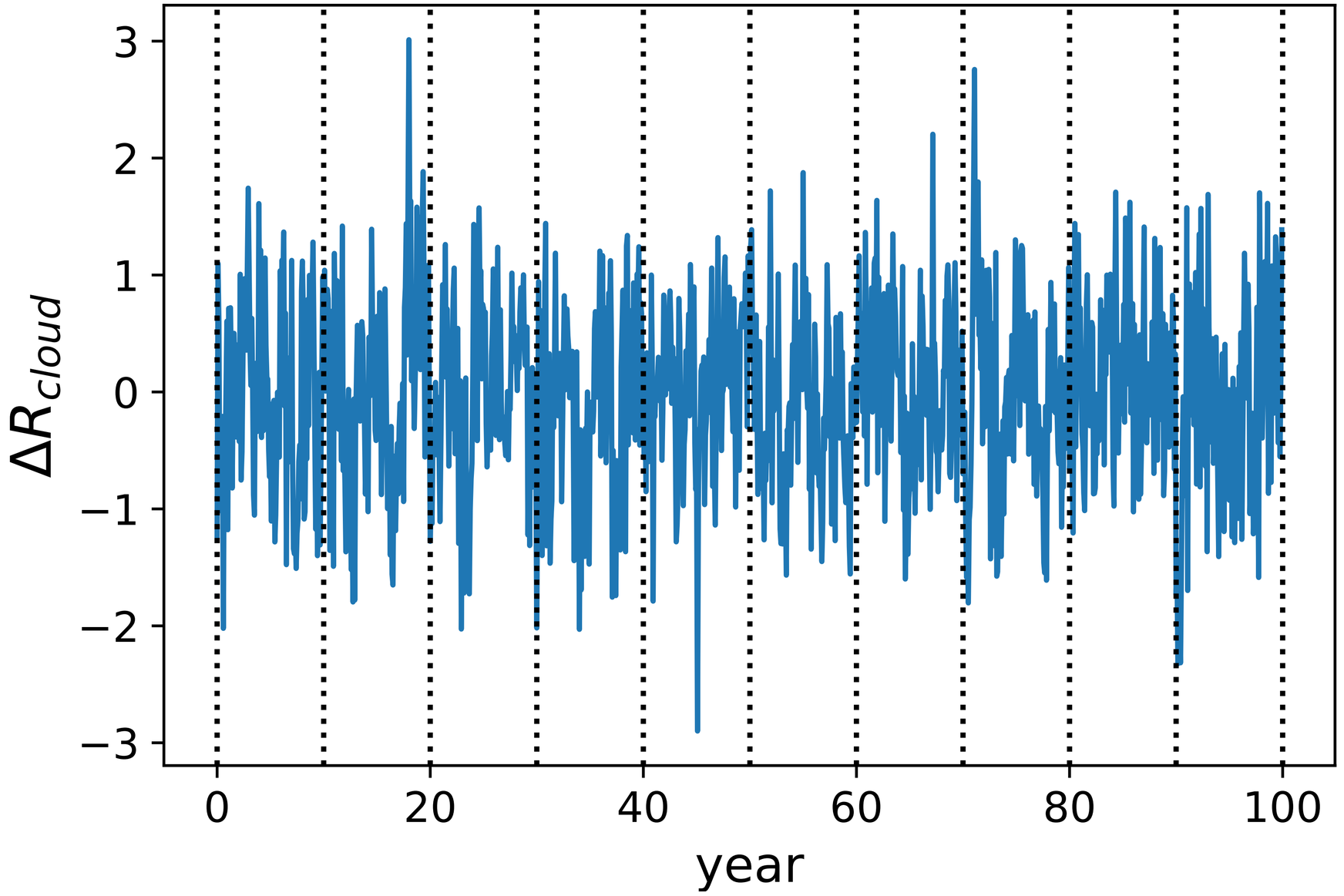
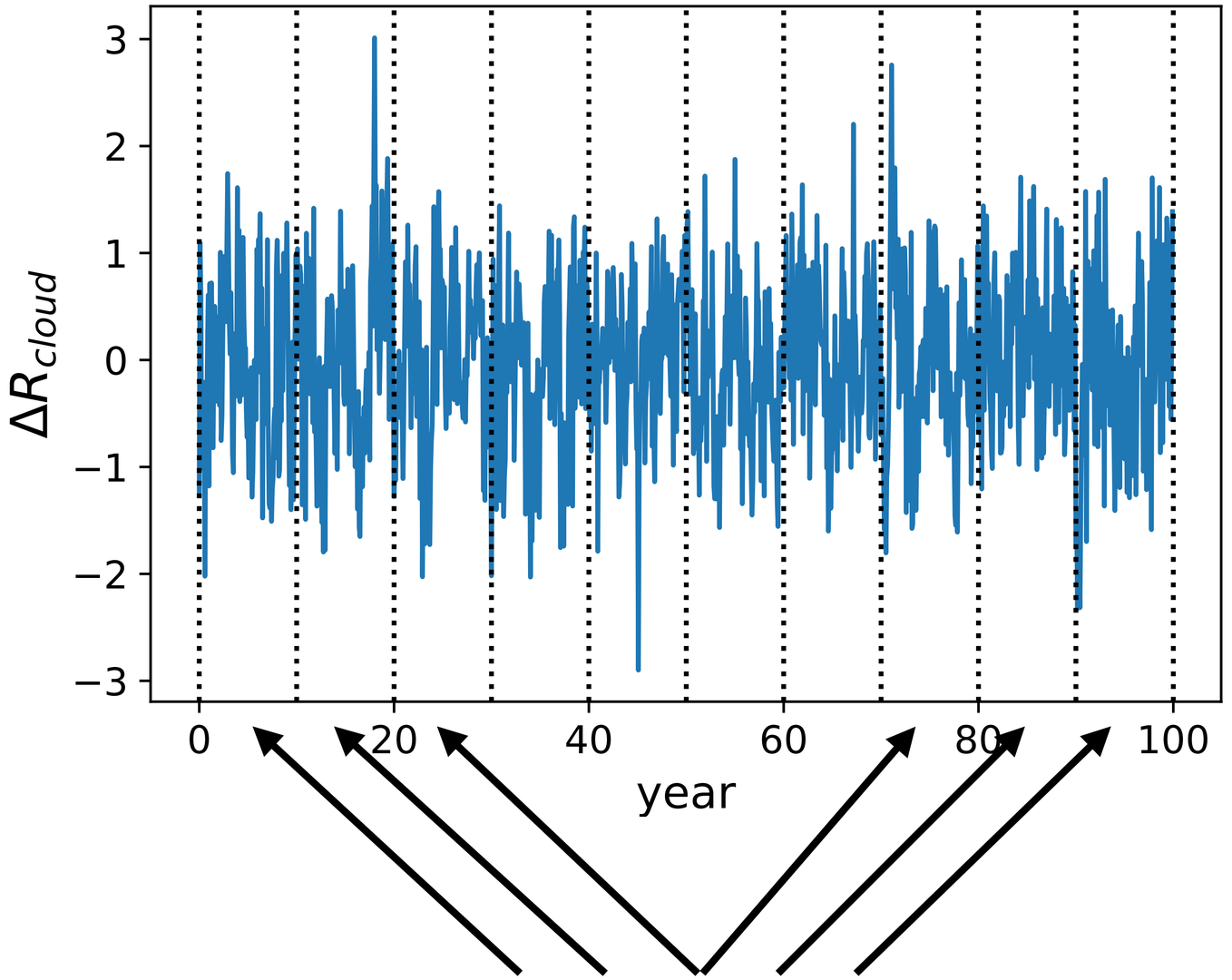
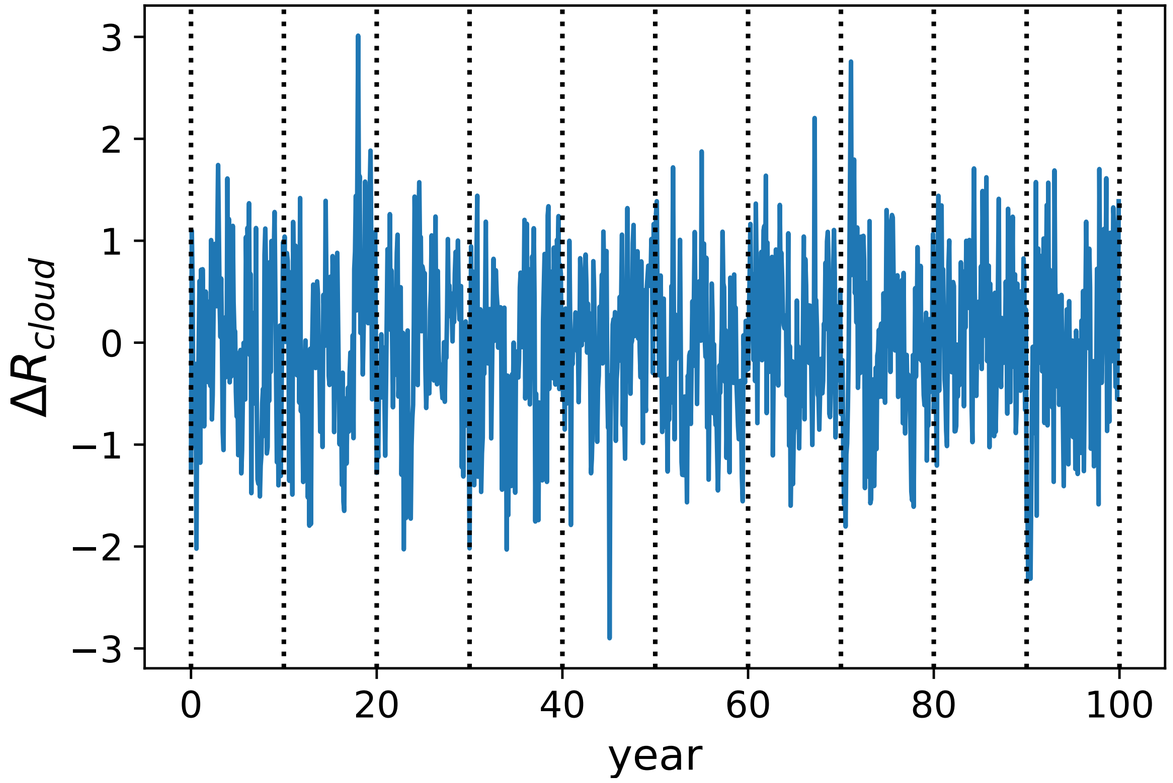




calculate cloud feedback in each 10-year segment

subtract feedback from consecutive periods



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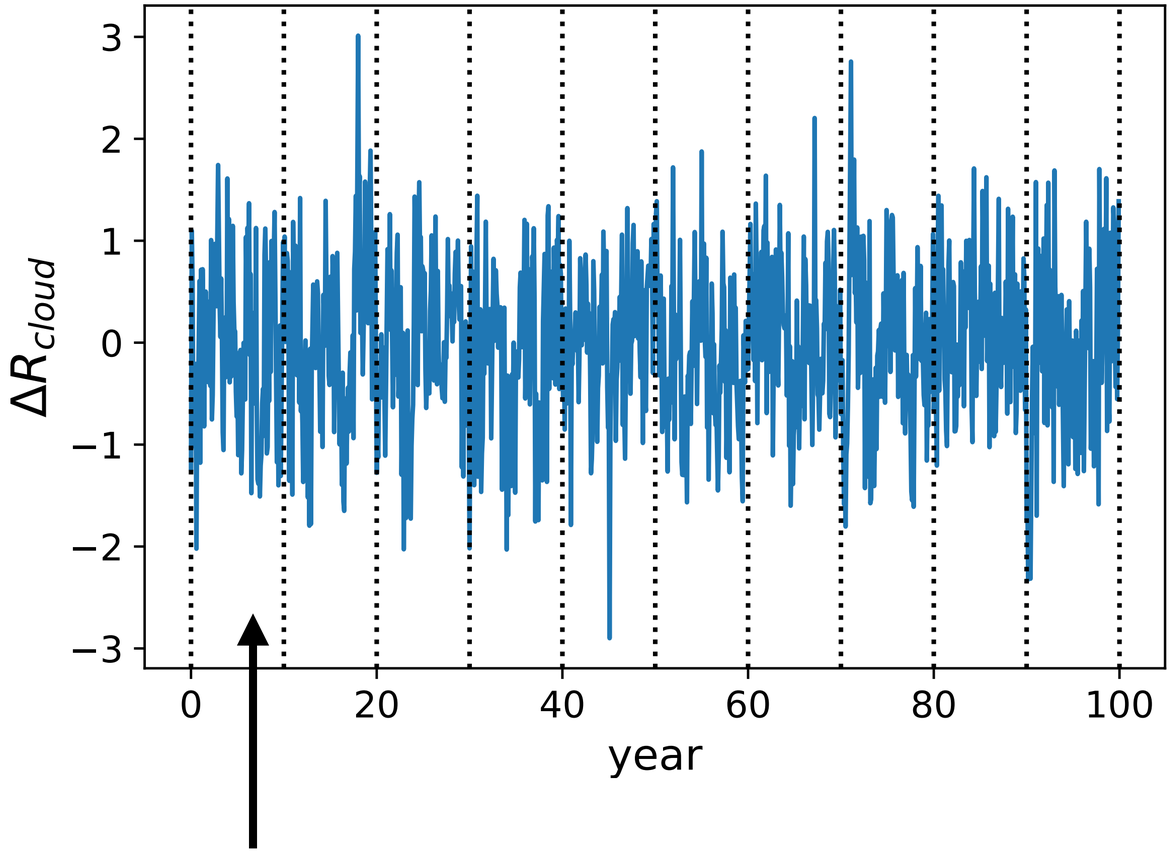
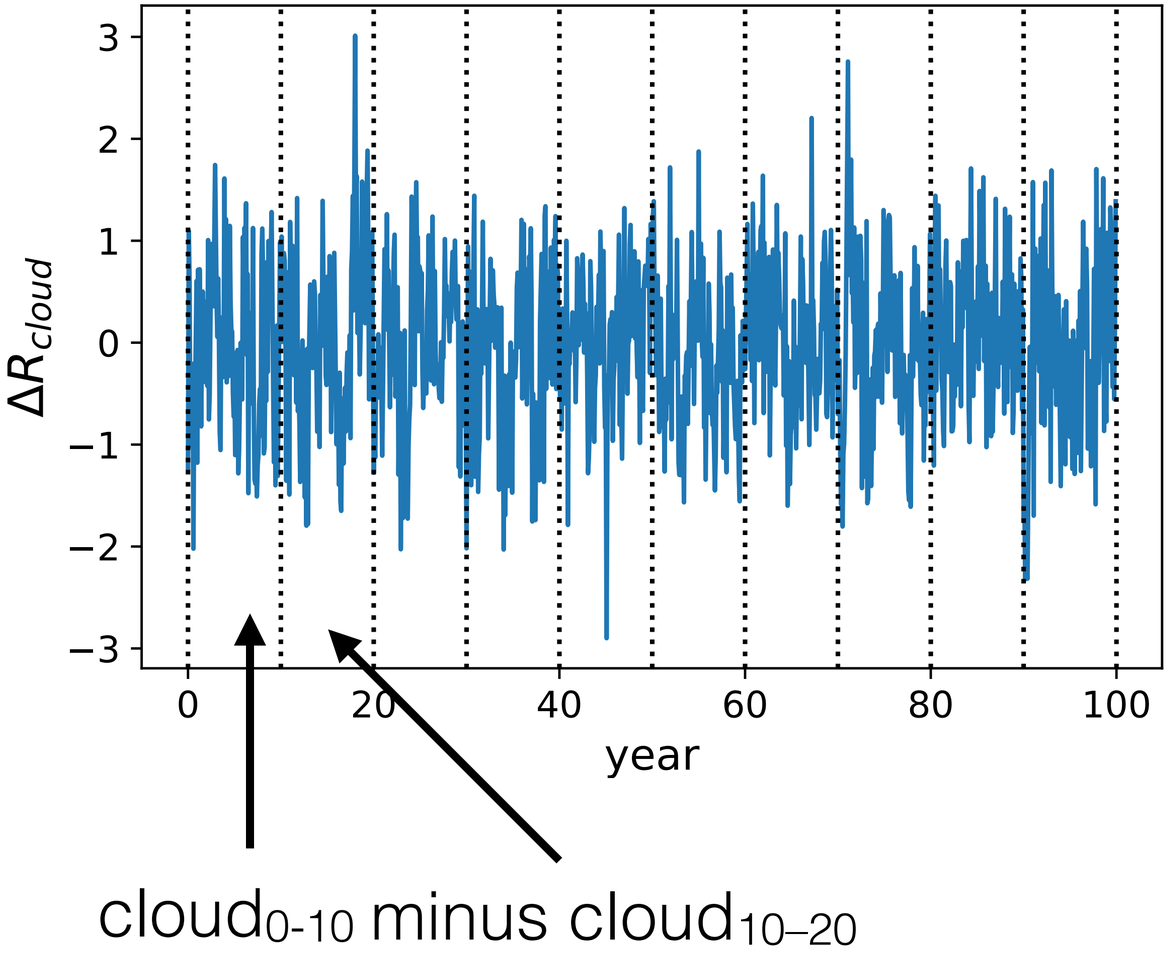


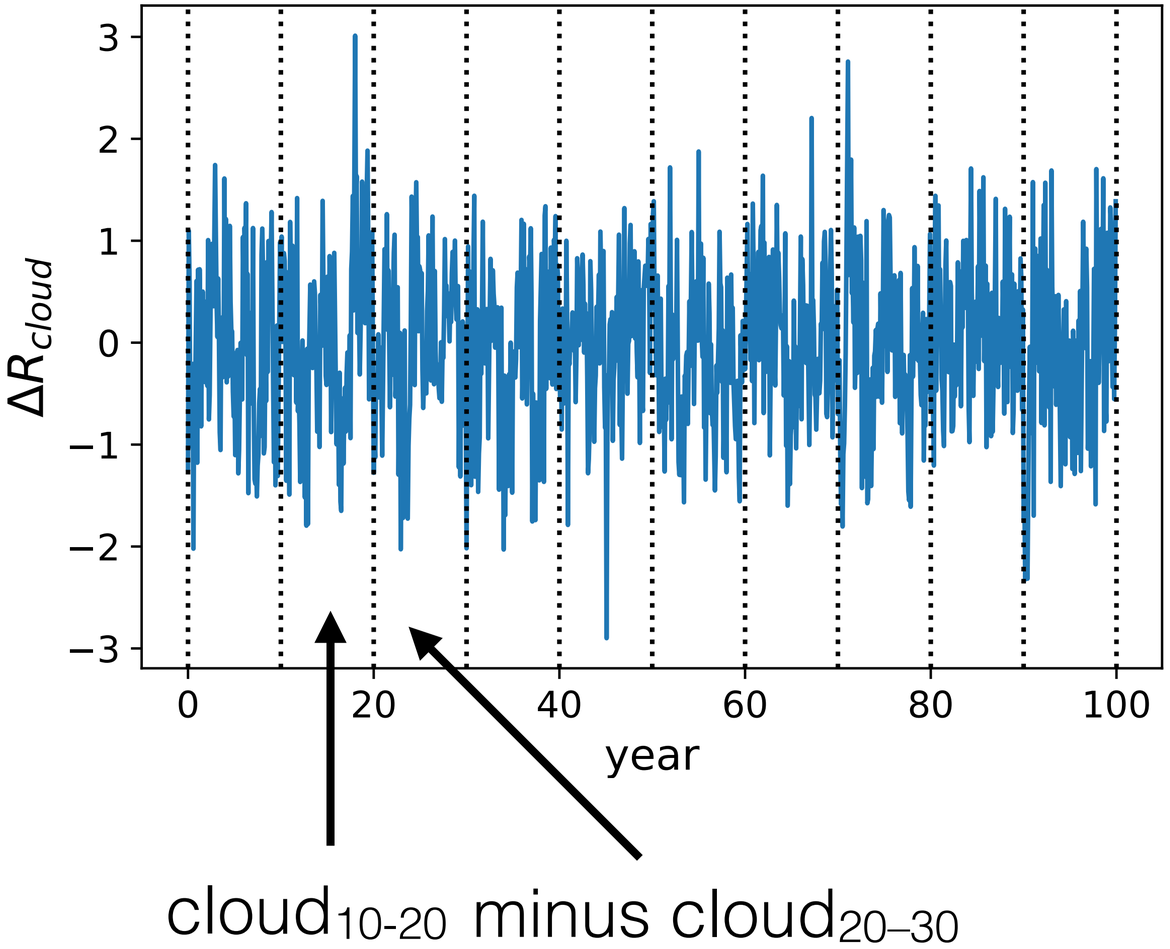
$cloud_{0\text{-}10}$

subtract feedback from consecutive periods



$cloud_{0\text{-}10}$ minus $cloud_{10\text{–}20}$

subtract feedback from consecutive periods



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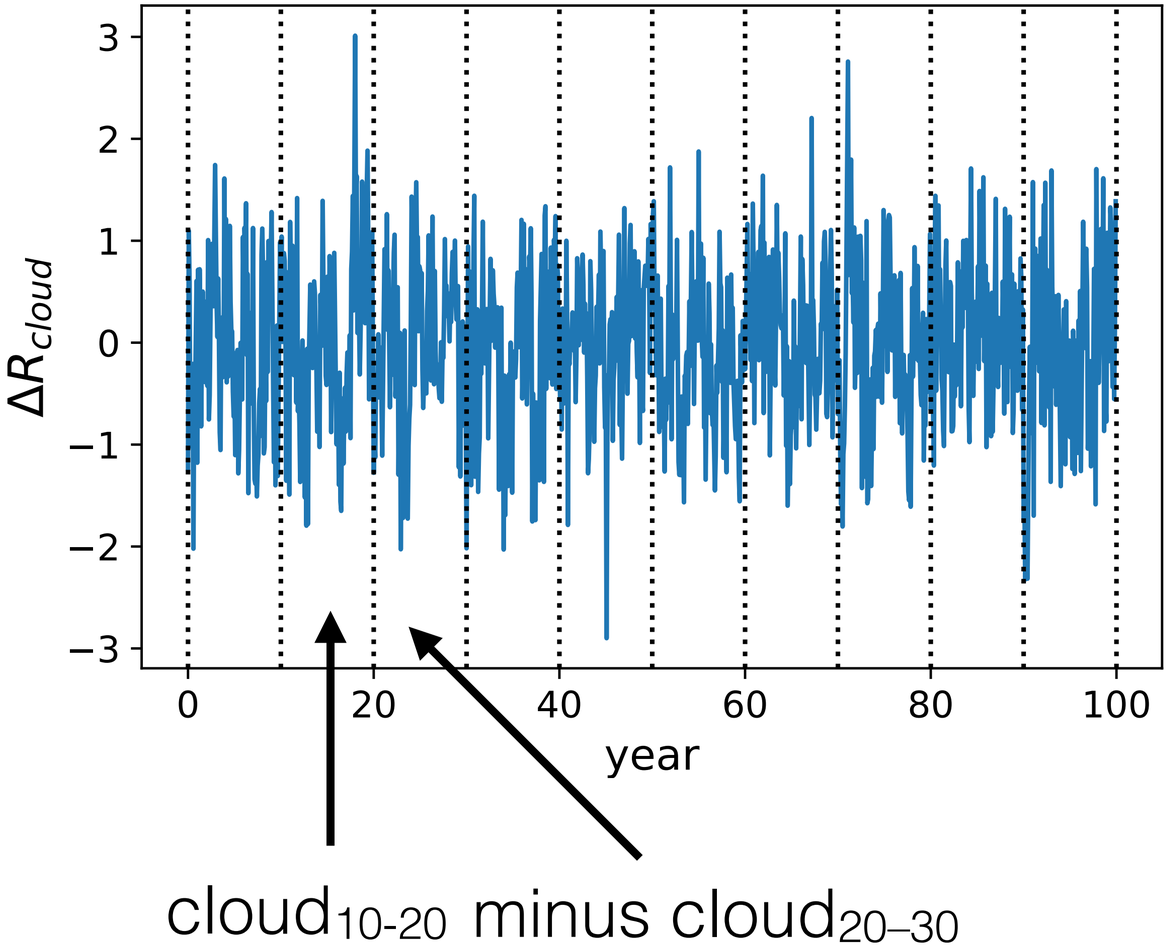
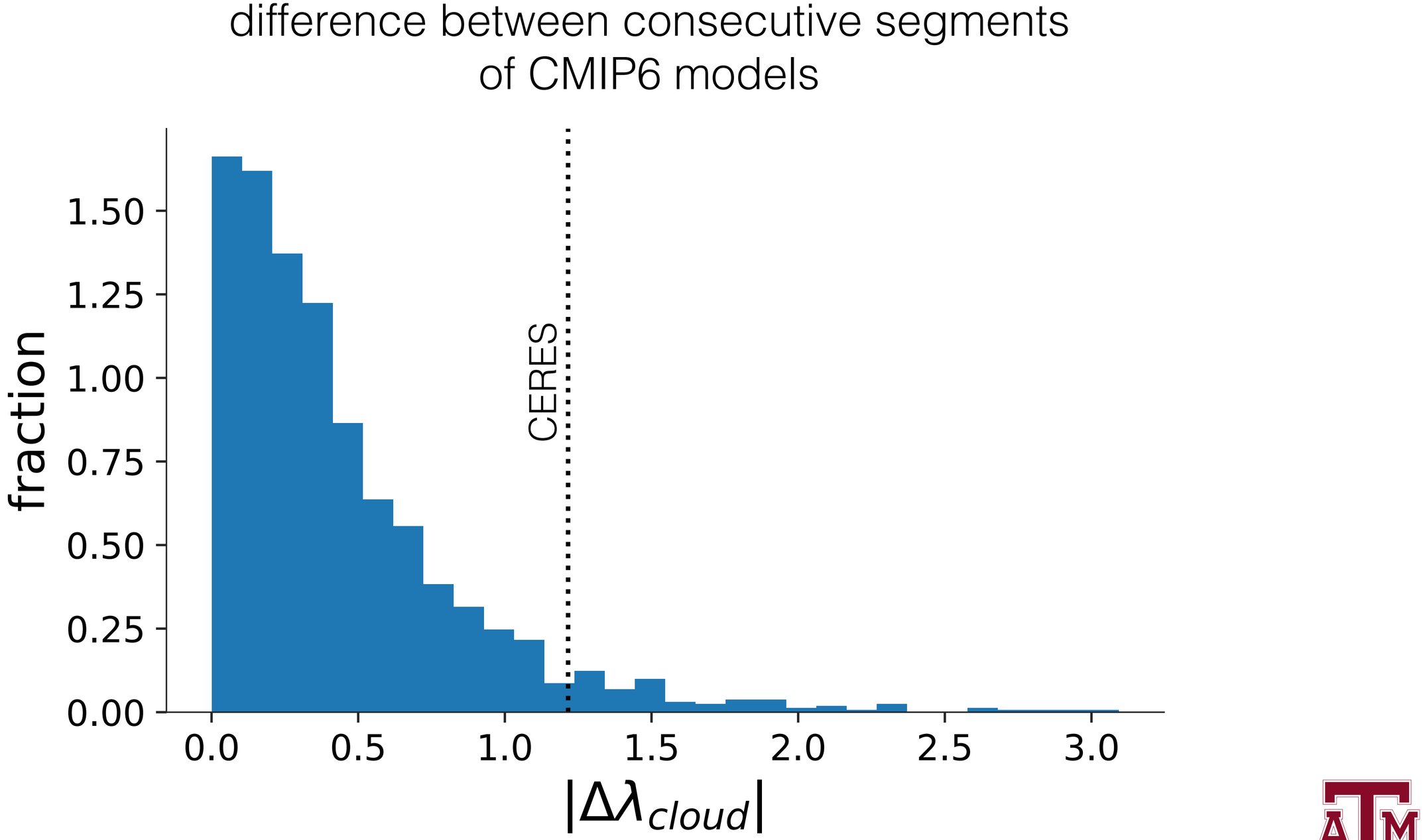
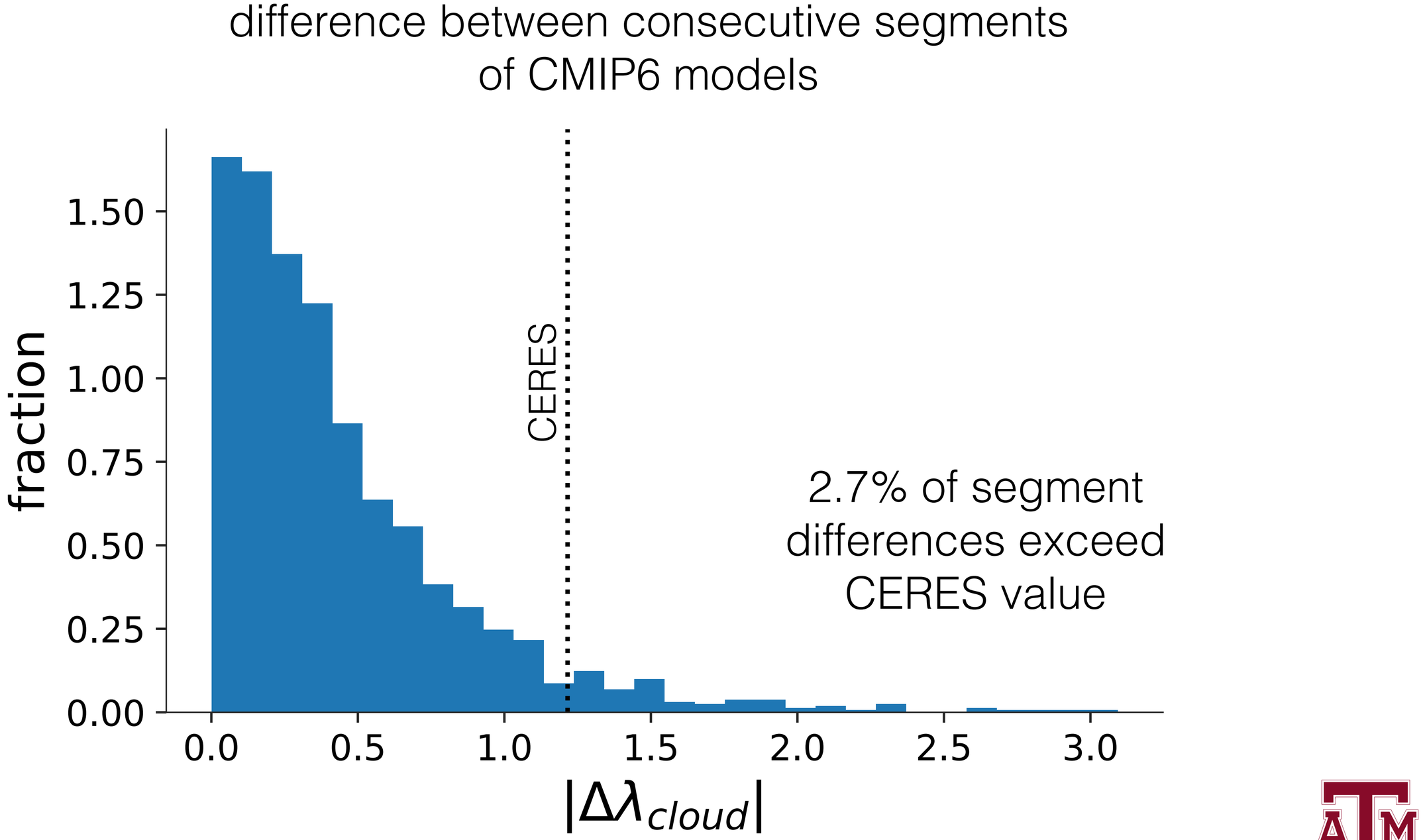


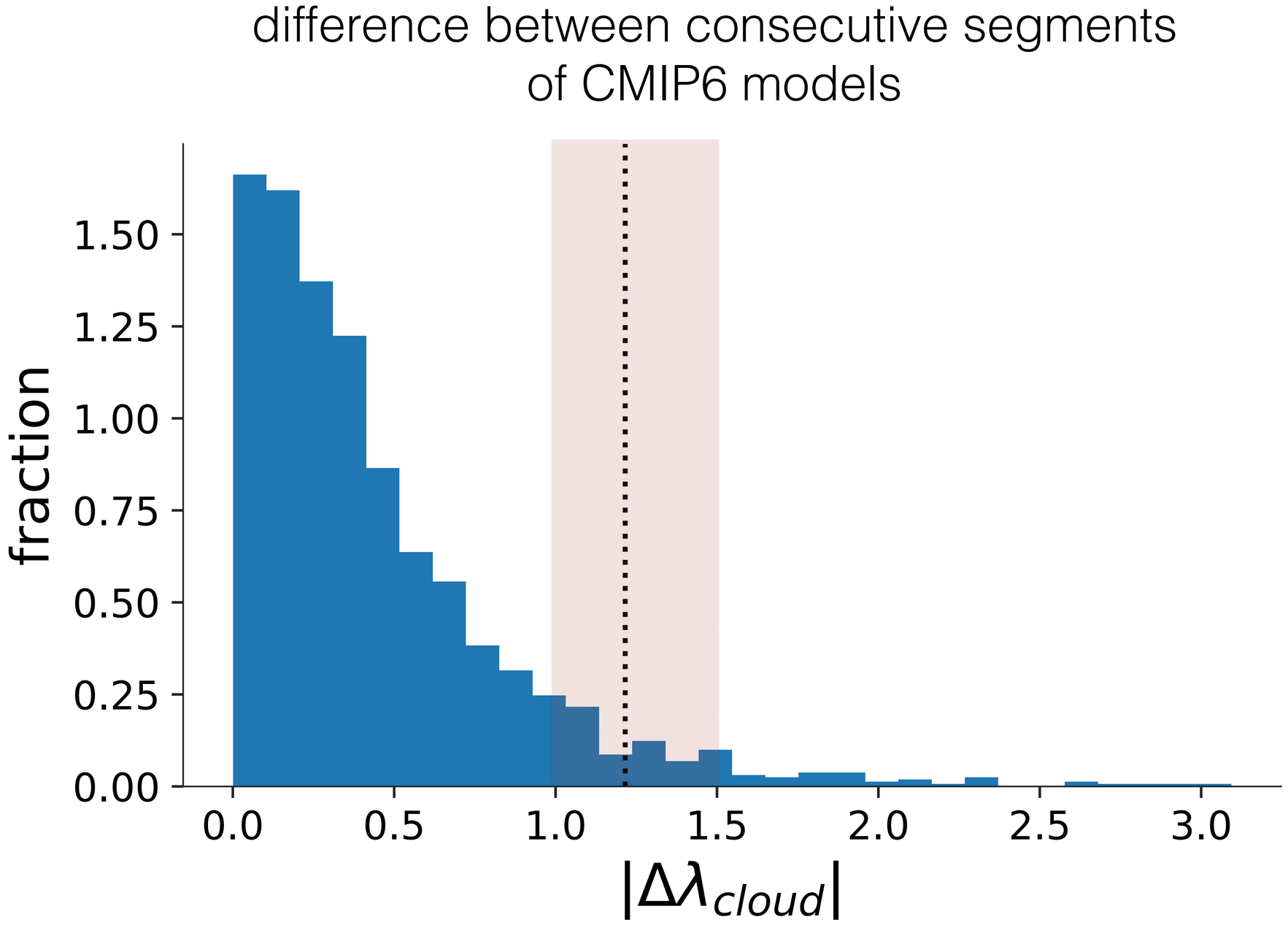
600 year control run:

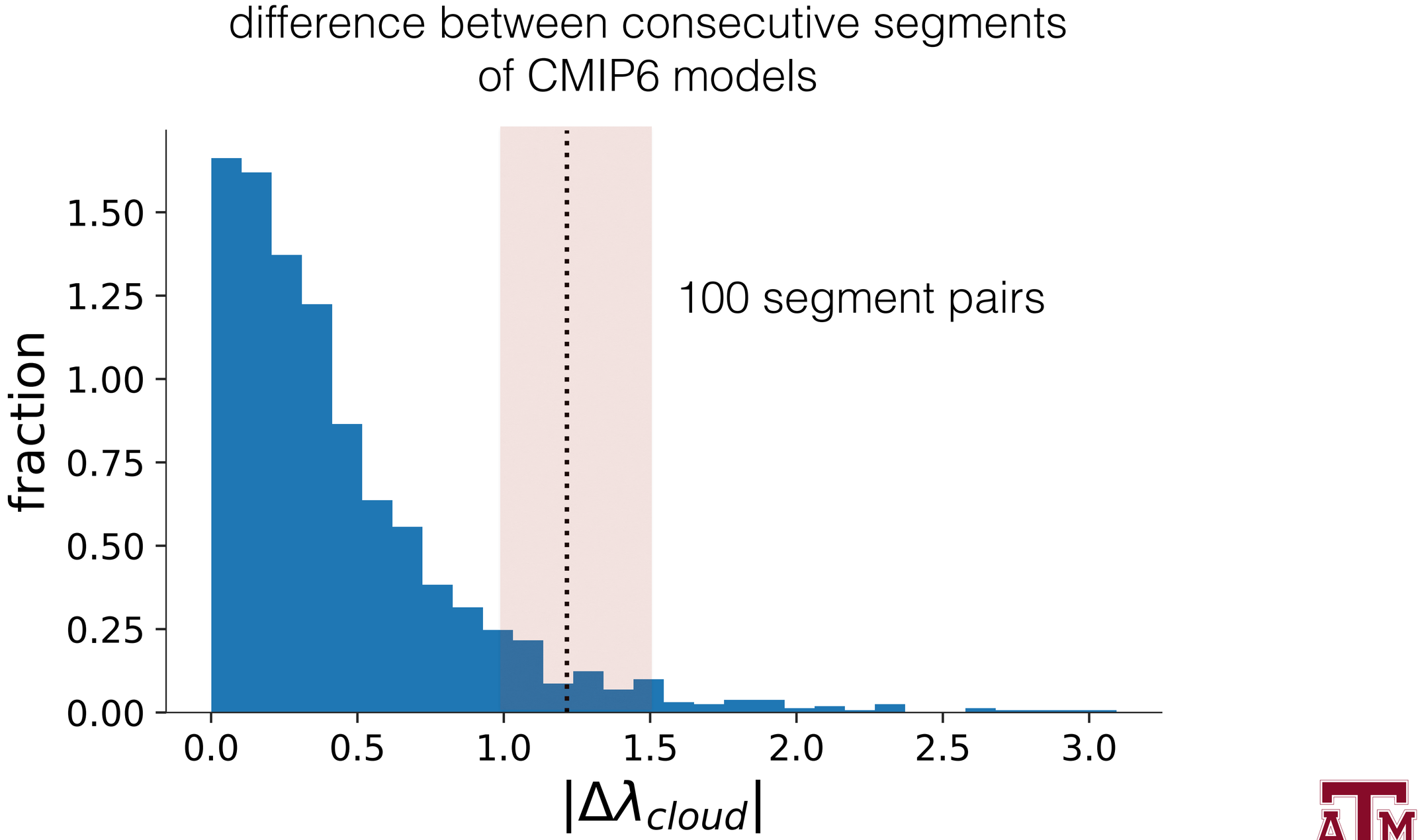
- 60 10-year segments
- 59 estimates of $\Delta\lambda_{cloud}$

26 CMIP6 models


difference between consecutive segments
of CMIP6 models
fraction
1.50
1.25
1.00
0.75
0.50
0.25
0.00
CERES
0.0
0.5
1.0
1.5
2.0
2.5
3.0
$|\Delta\lambda_{cloud}|$

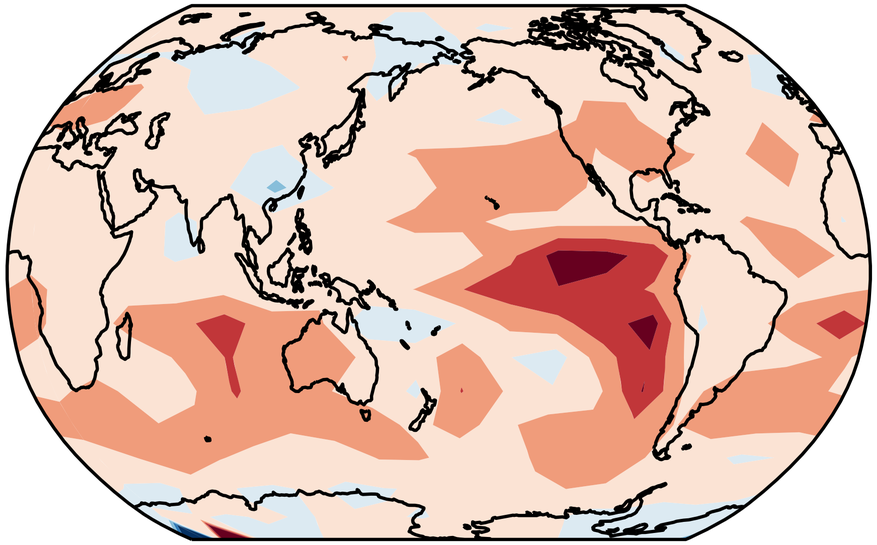

difference between consecutive segments
of CMIP6 models
fraction
1.50
1.25
1.00
0.75
0.50
0.25
0.00
CERES
2.7% of segment
differences exceed
CERES value
0.0
0.5
1.0
1.5
2.0
2.5
3.0
$|\Delta\lambda_{cloud}|$

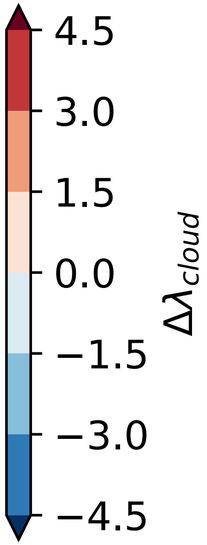

difference between consecutive segments
of CMIP6 models
fraction
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
$|\Delta\lambda_{cloud}|$


difference between consecutive segments
of CMIP6 models
100 segment pairs
fraction
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
$|\Delta\lambda_{cloud}|$

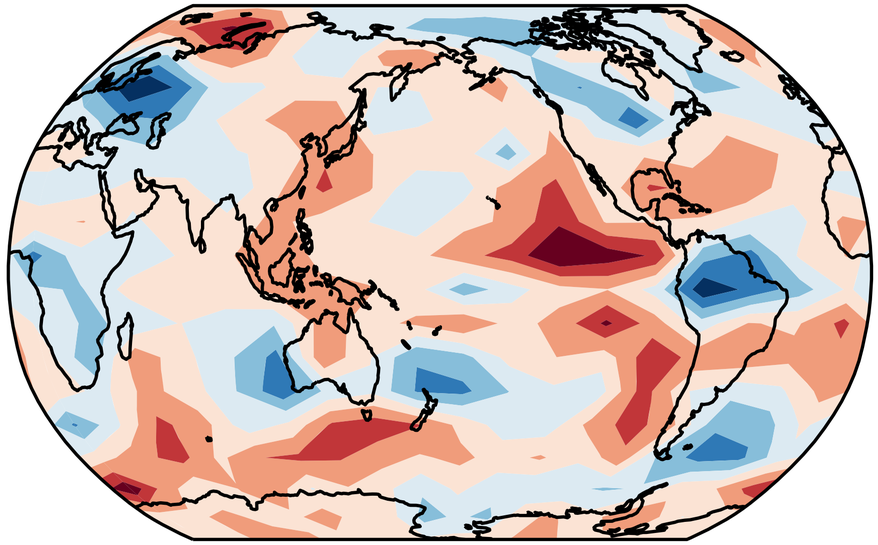
100

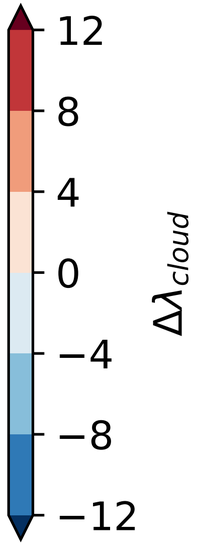
model & segment average



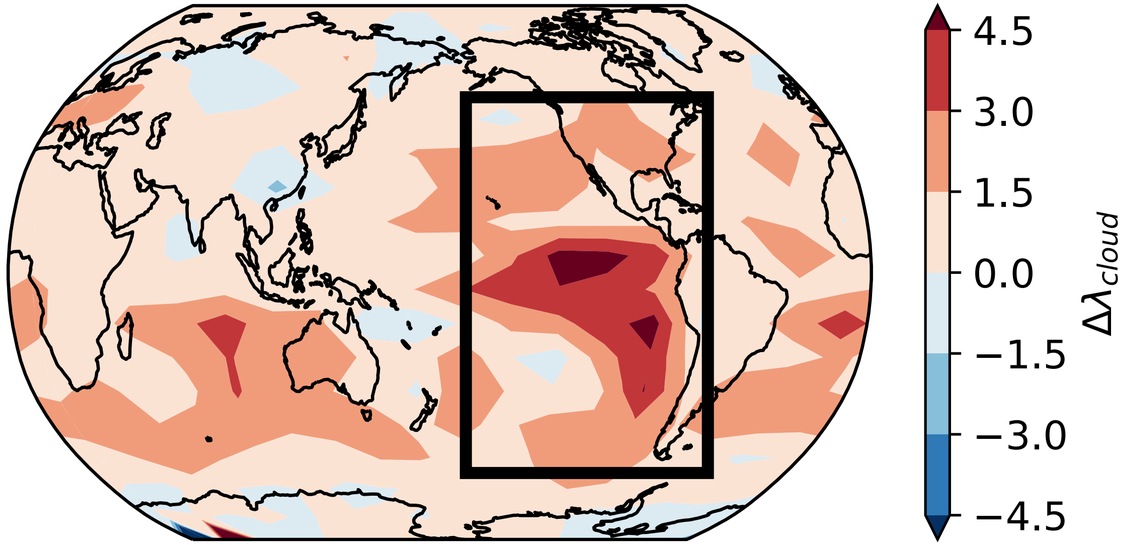


CERES+ERA5

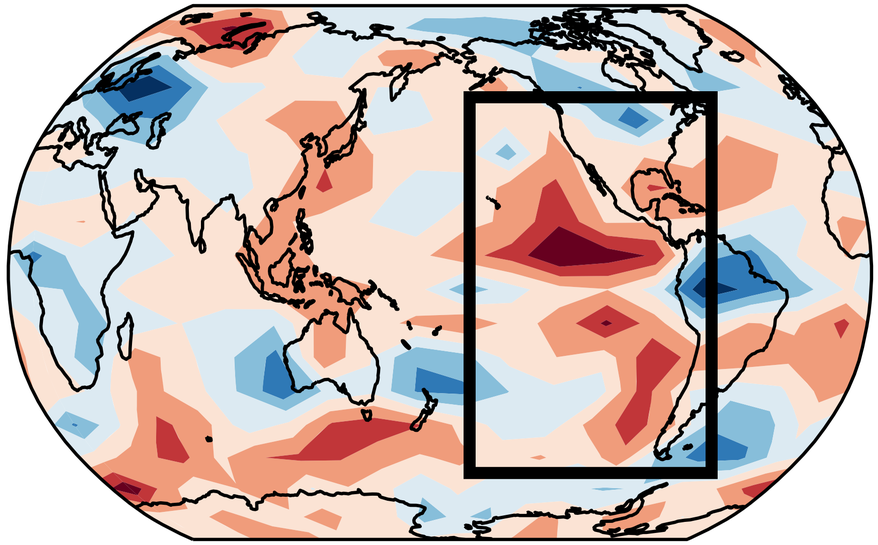


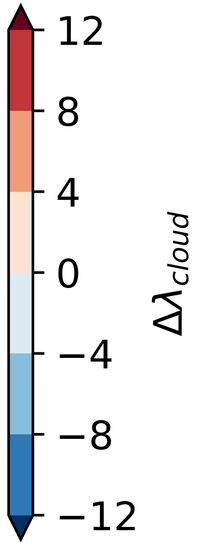


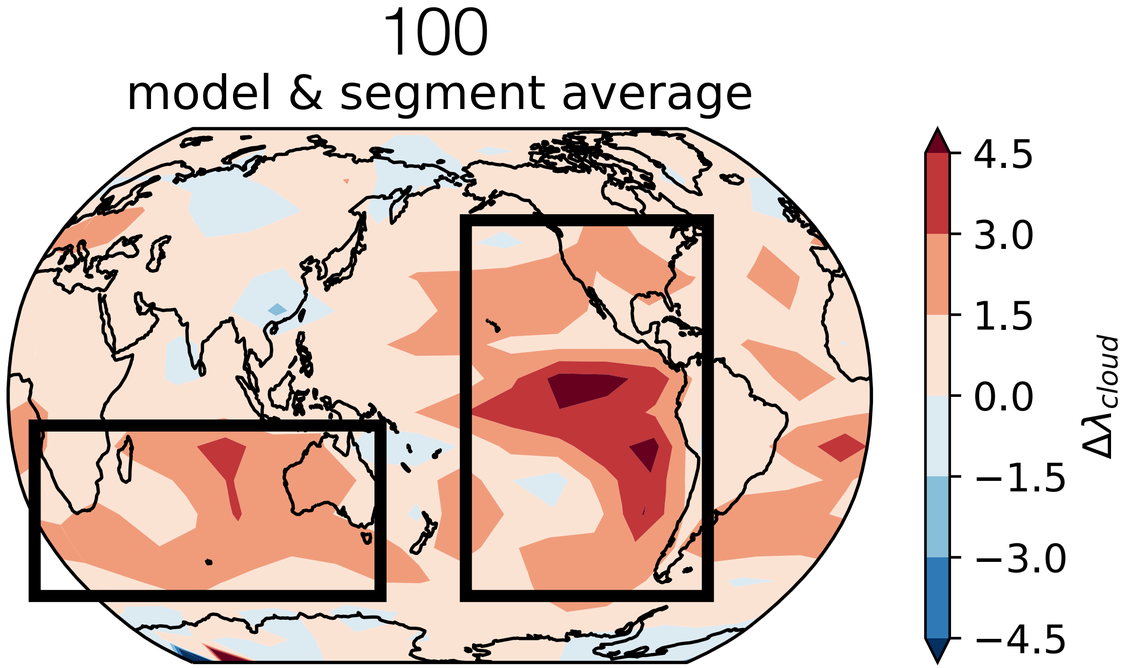
100
model & segment average

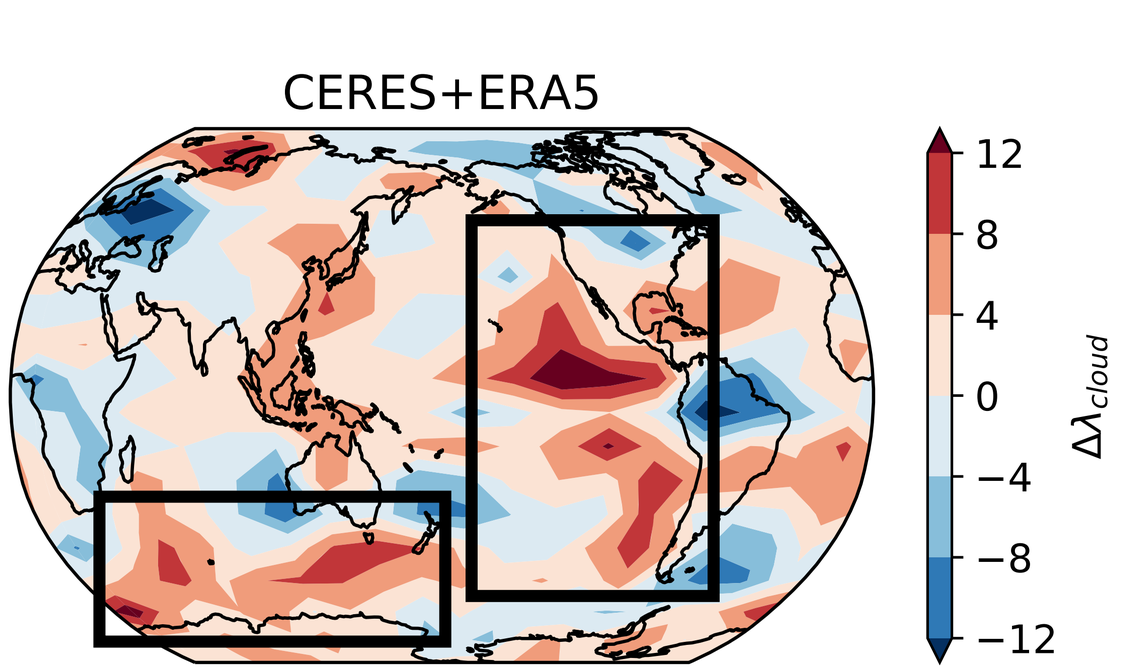


CERES+ERA5

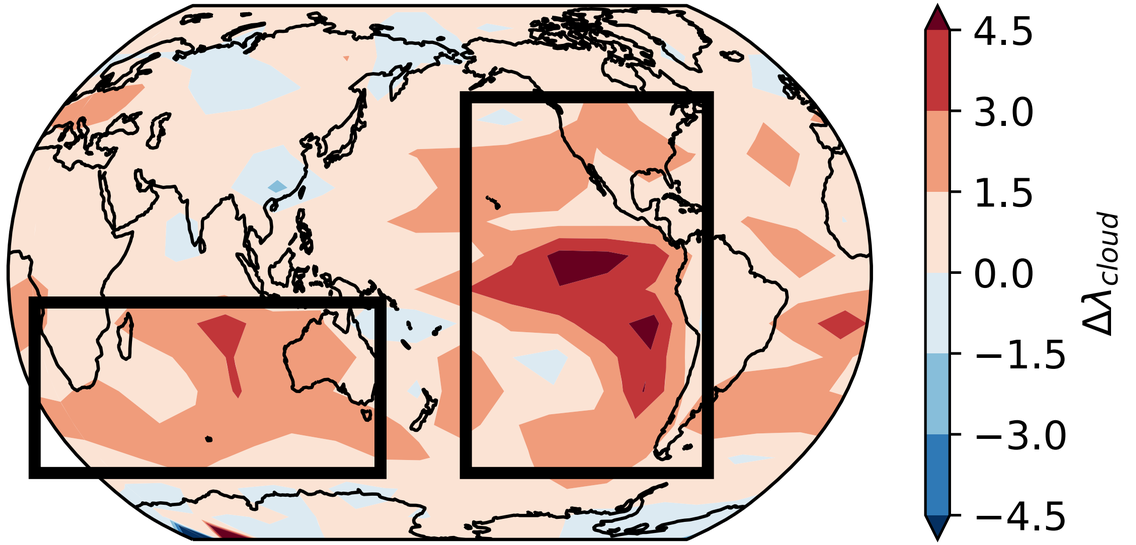




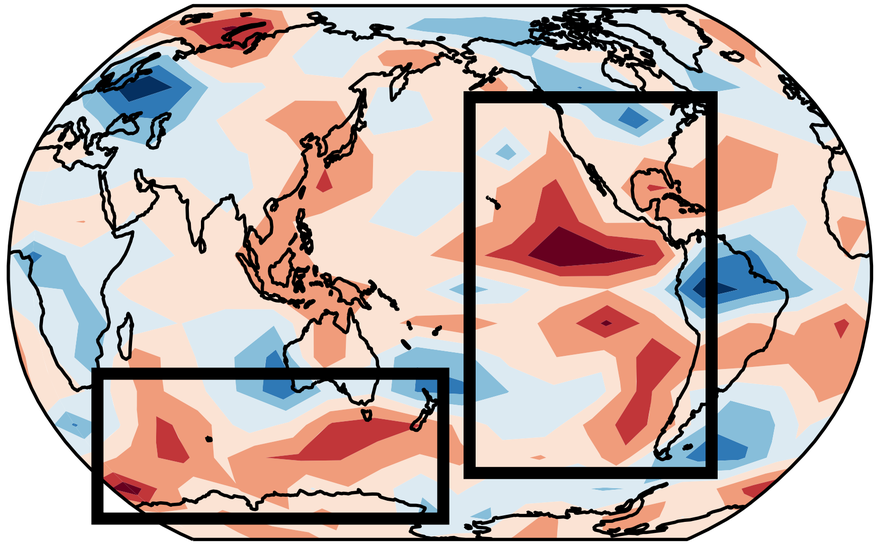

100
model & segment average
4.5
3.0
1.5
0.0
−1.5
−3.0
−4.5
$\Delta\lambda_{cloud}$

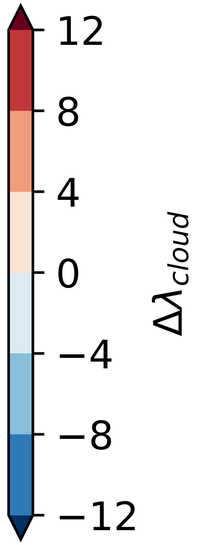

CERES+ERA5
12
8
4
0
−4
−8
−12
$\Delta\lambda_{cloud}$

100
model & segment average



CERES+ERA5





Geophysical Research Letters

RESEARCH LETTER
10.1029/2019GL086705

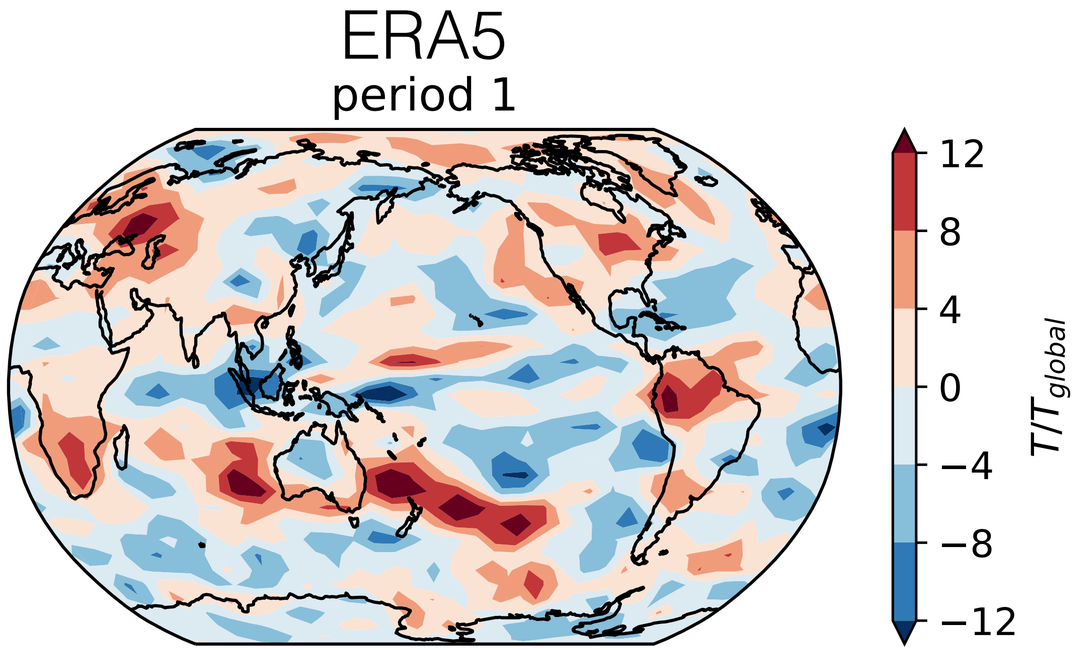
Key Points:

- There is good agreement between radiation budget variations observed by CERES and simulated by seven state-of-the-art climate models
- The relationship between global mean net TOA radiation and surface temperature is sensitive to changes in regions dominated by low clouds
- Most models underestimate

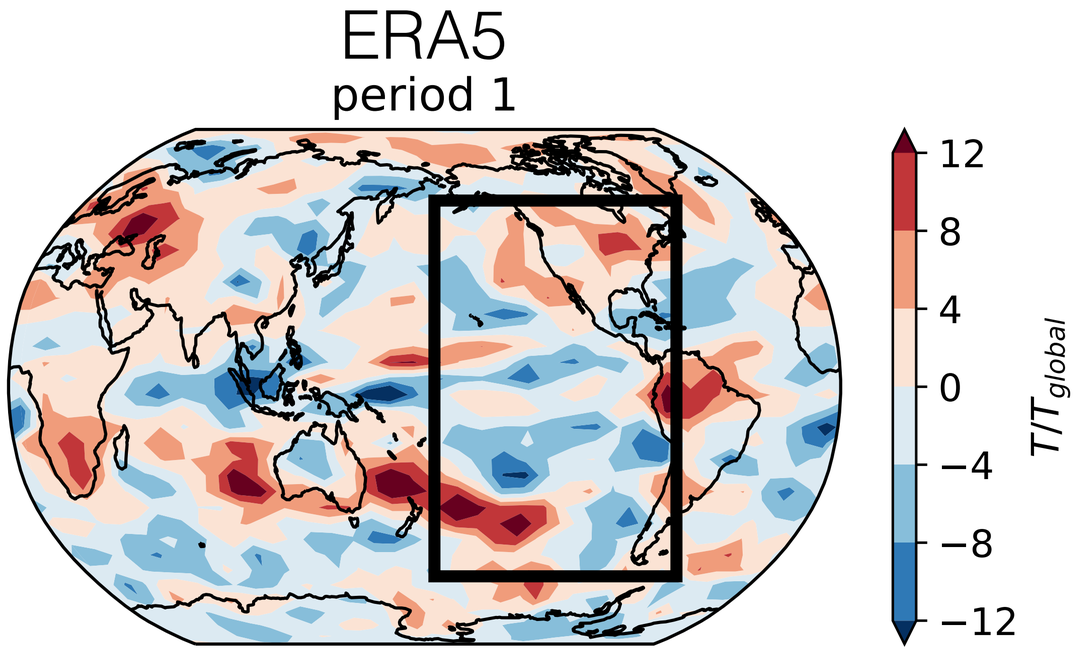
New Generation of Climate Models Track Recent Unprecedented Changes in Earth's Radiation Budget Observed by CERES

Norman G. Loeb[1], Hailan Wang[2], Richard P. Allan[3], Timothy Andrews[4], Kyle Armour[5], Jason N. S. Cole[6], Jean-Louis Dufresne[7], Piers Forster[8], Andrew Gettelman[9], Huan Guo[10], Thorsten Mauritsen[11], Yi Ming[10], David Paynter[10], Cristian Proistosescu[12,13], Malte F. Stuecker[14], Ulrika Willén[15], and Klaus Wyser[15]

regression at temperature at each grid point vs. global avg. temperature



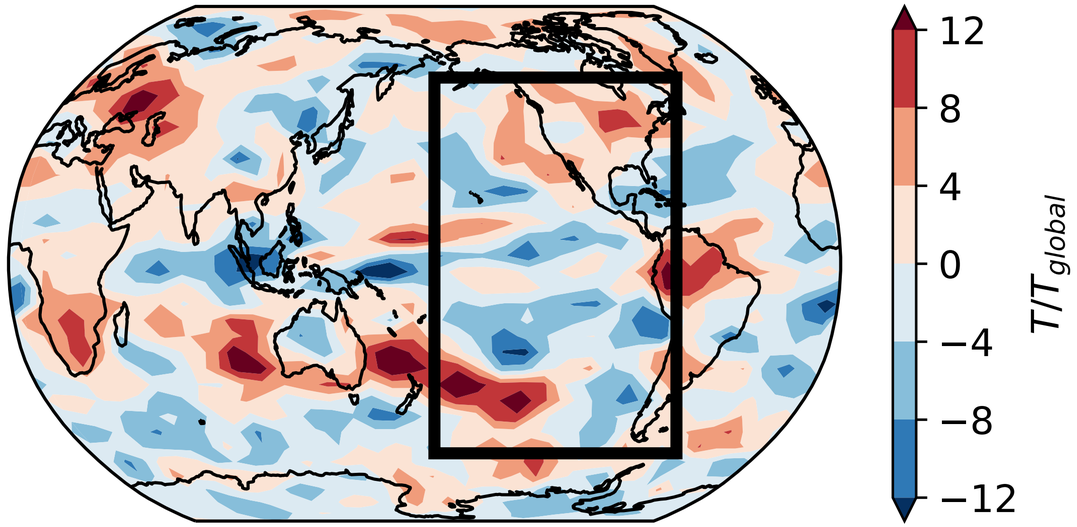
regression at temperature at each grid point vs. global avg. temperature



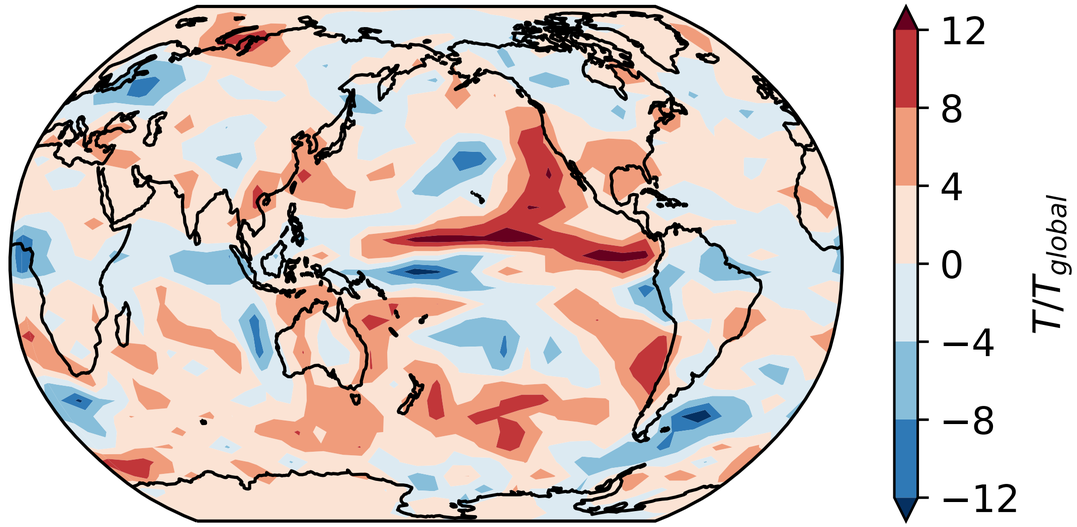
as the globe warms, there
is little warming in the E. Pacific

regression at temperature at each grid point vs. global avg. temperature

ERA5
period 1



ERA5
period 2



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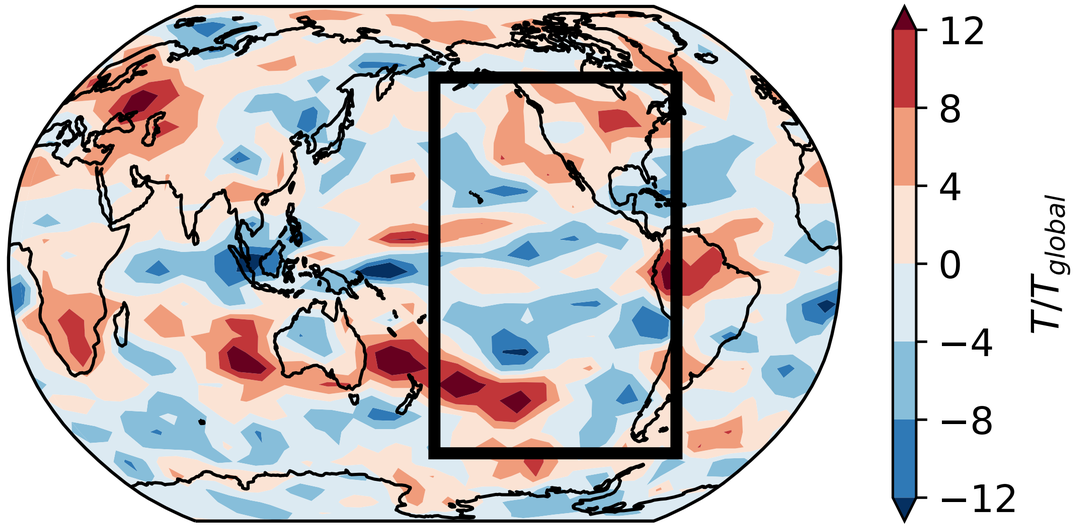
regression at temperature at each grid point vs. global avg. temperature

ERA5
period 1



as the globe warms, there
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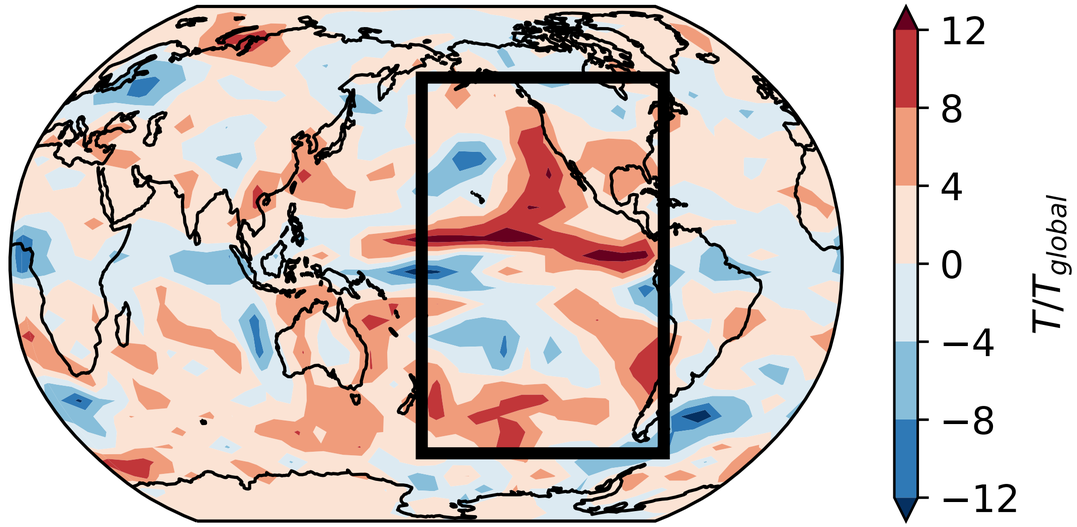
ERA5
period 2



as the globe warms, there
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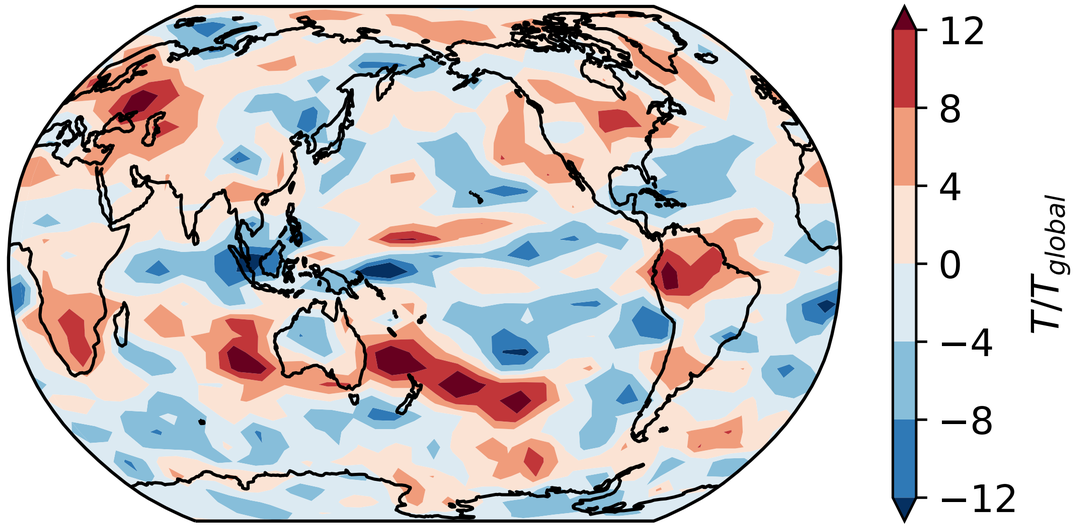
regression at temperature at each grid point vs. global avg. temperature

ERA5
period 1



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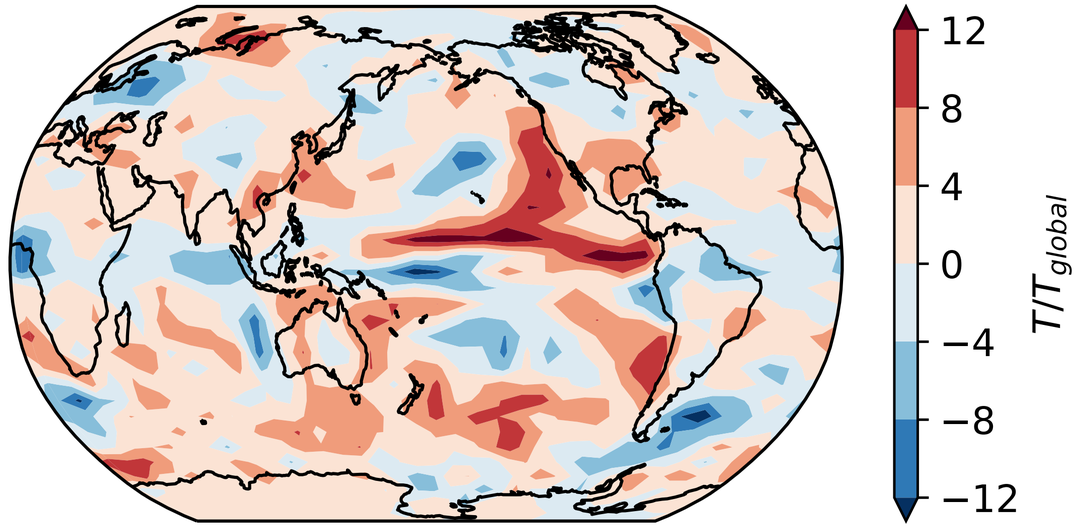
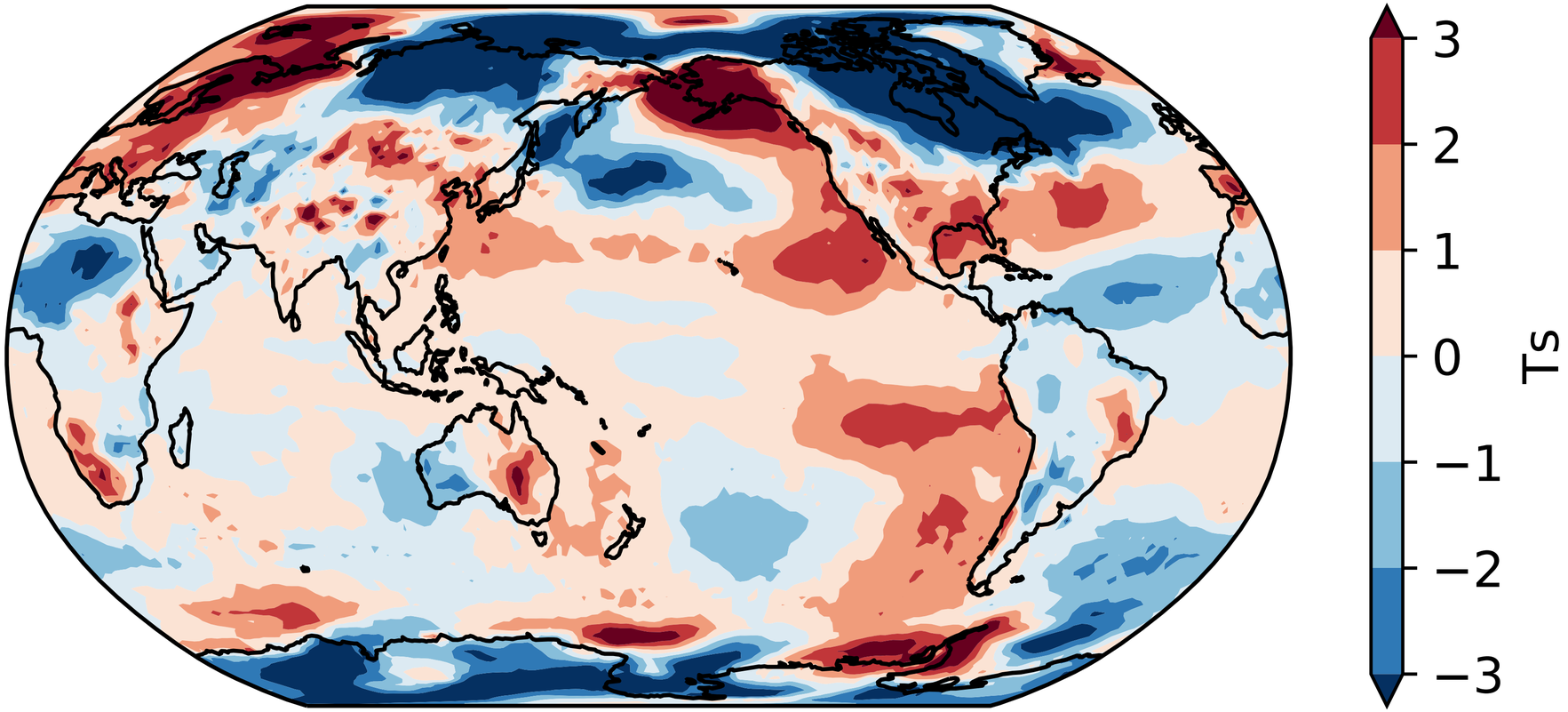
ERA5
period 2



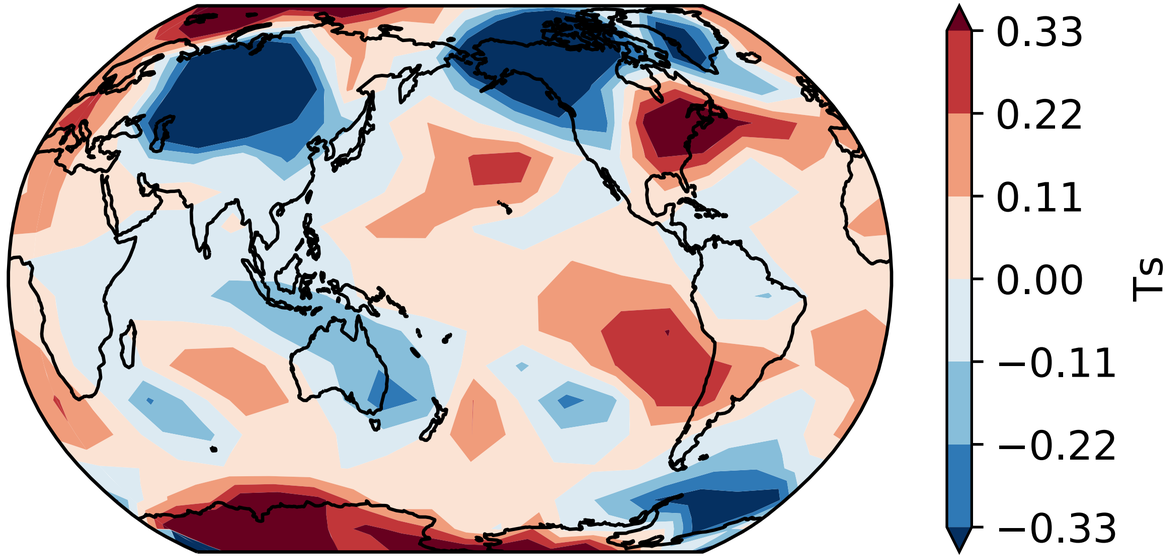
as the globe warms, there
is a lot of warming in the E. Pacific

difference in temperature slope (K/K)

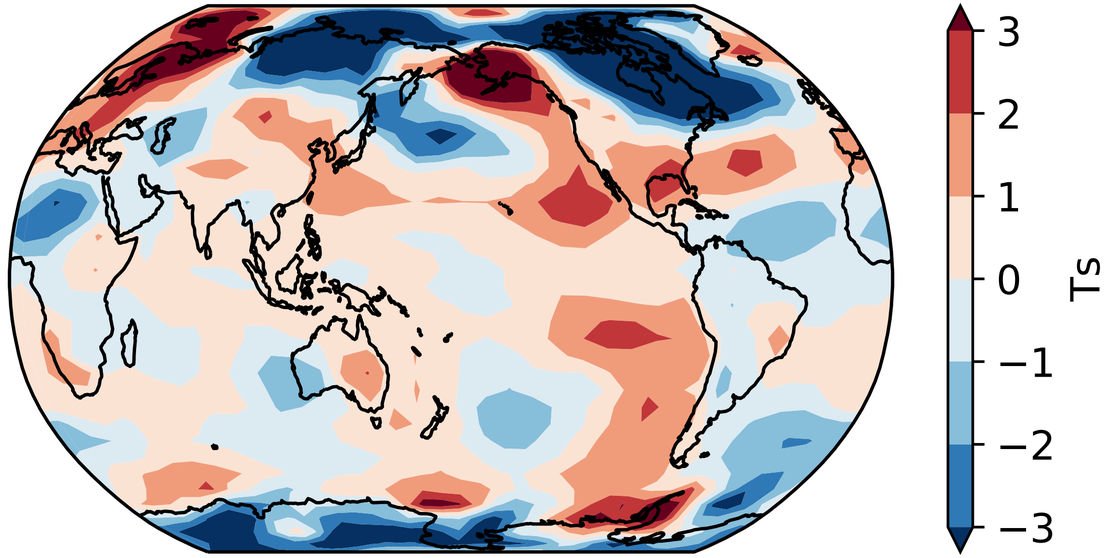


ERA5 period 2 minus period 1

model & segment average

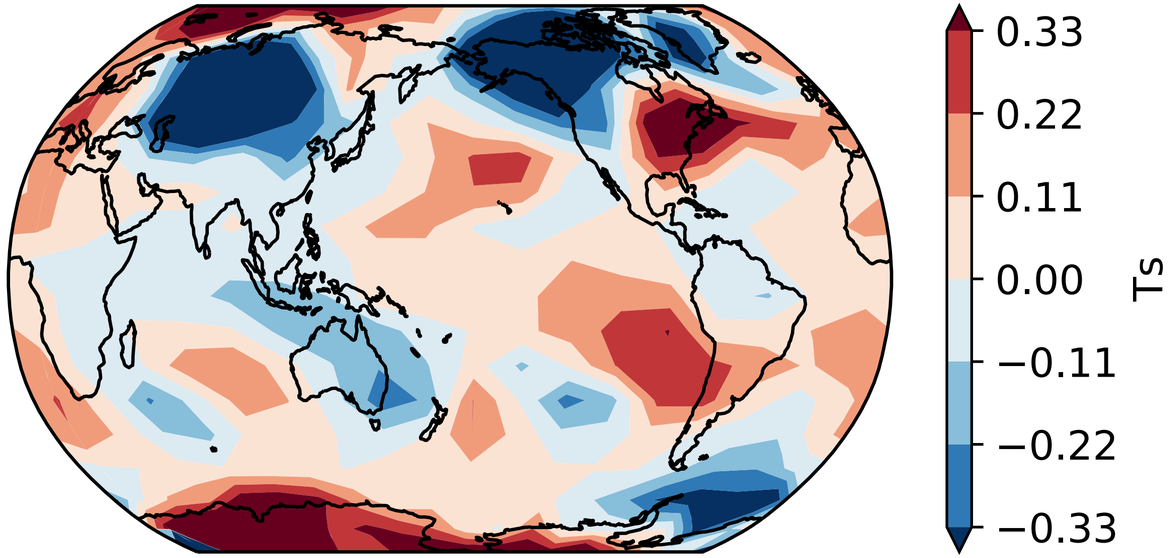


CERES+ERA5

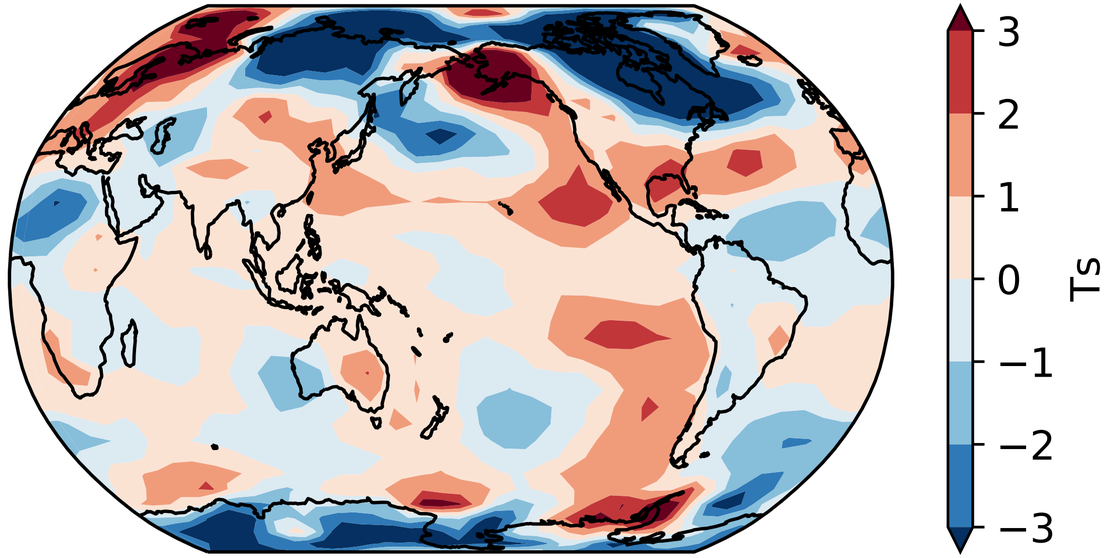


average of 100 consecutive segments with large differences in cloud feedback

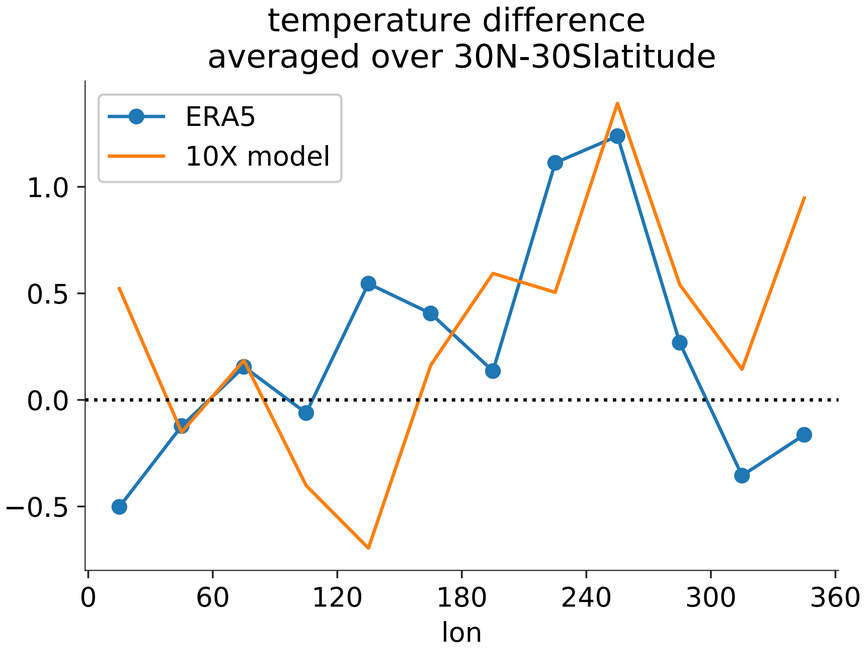
model & segment average



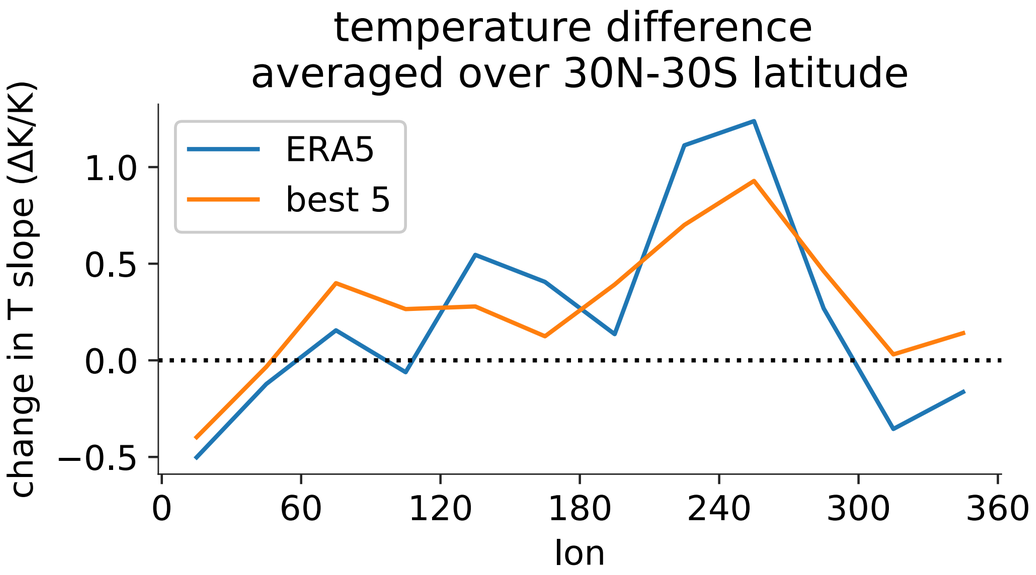
CERES+ERA5



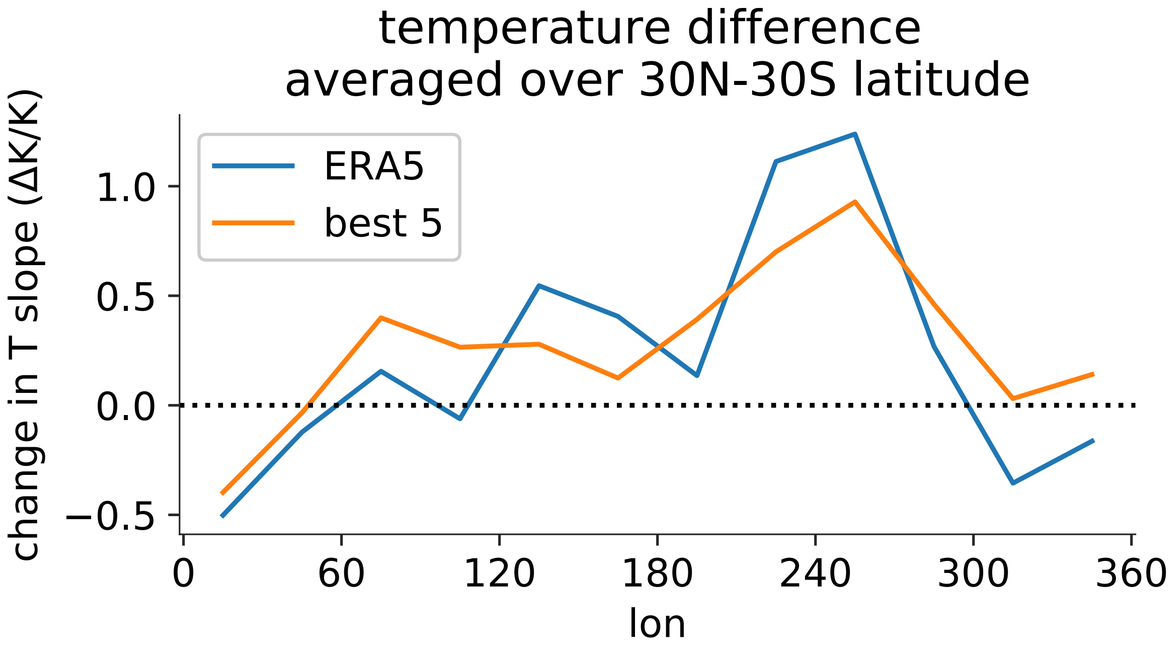
average of 100 consecutive segments with large differences in cloud feedback

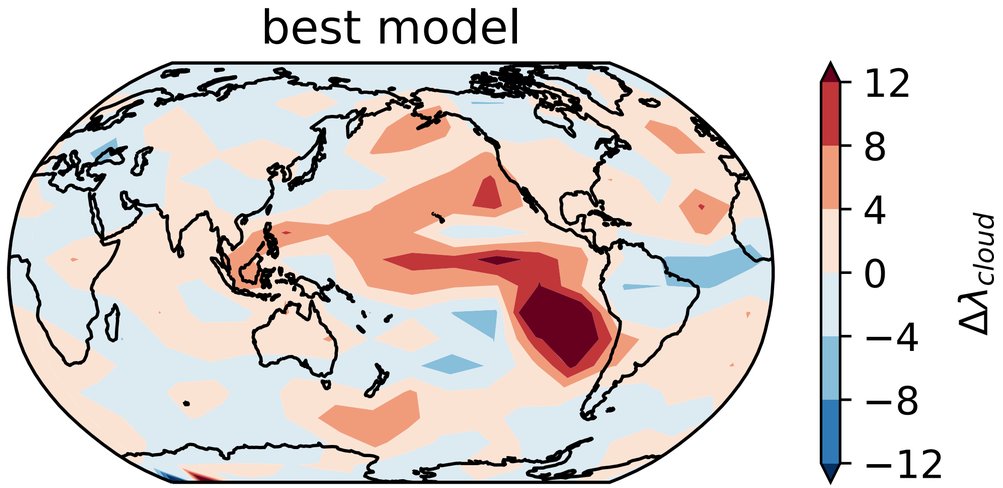


tropical average



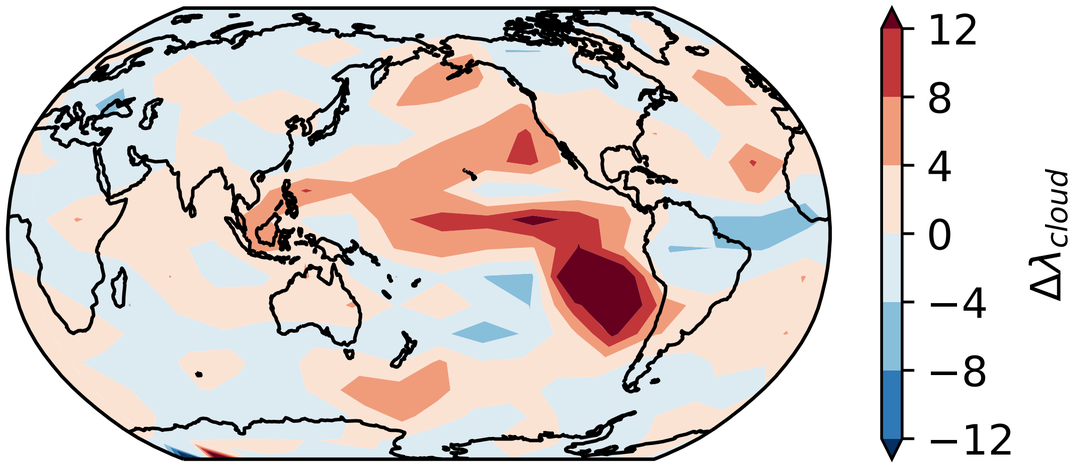
select five segment pairs that have the closest correspondence to ΔT observations



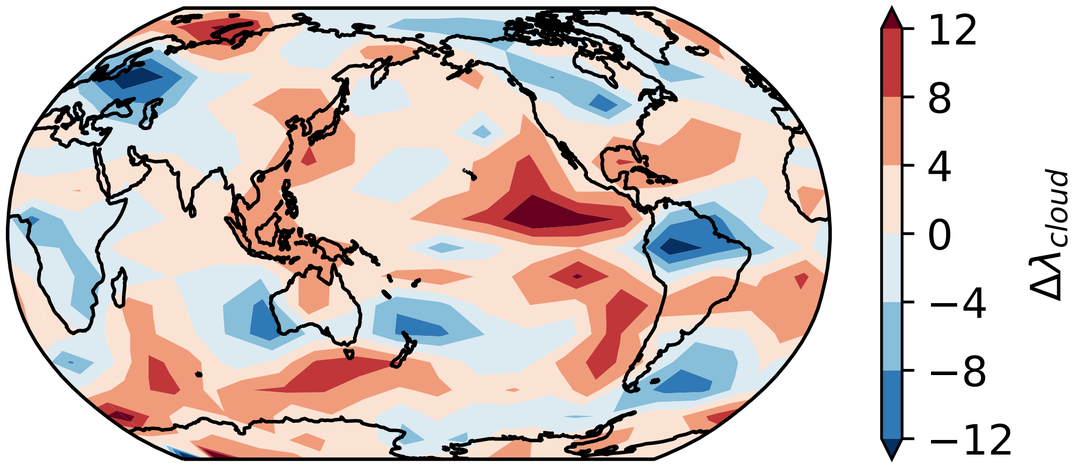


difference in
cloud feedback

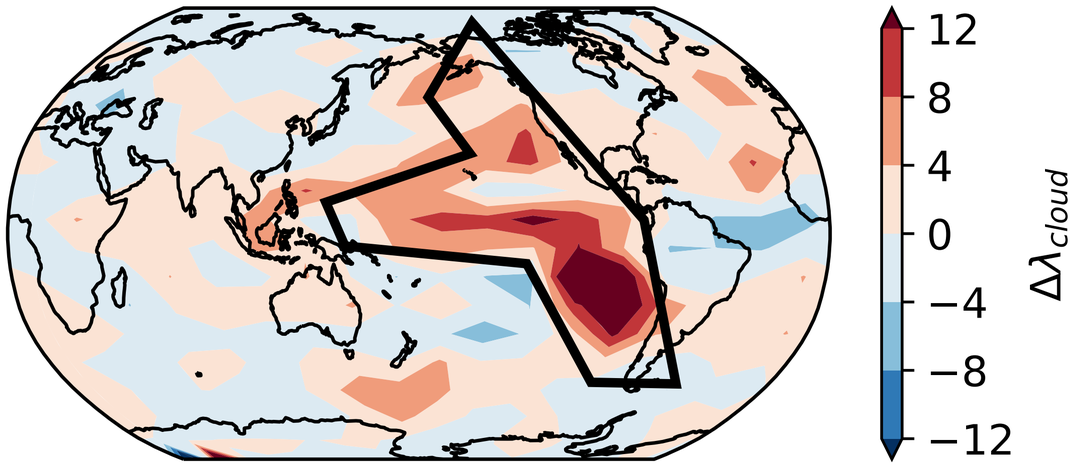
best model



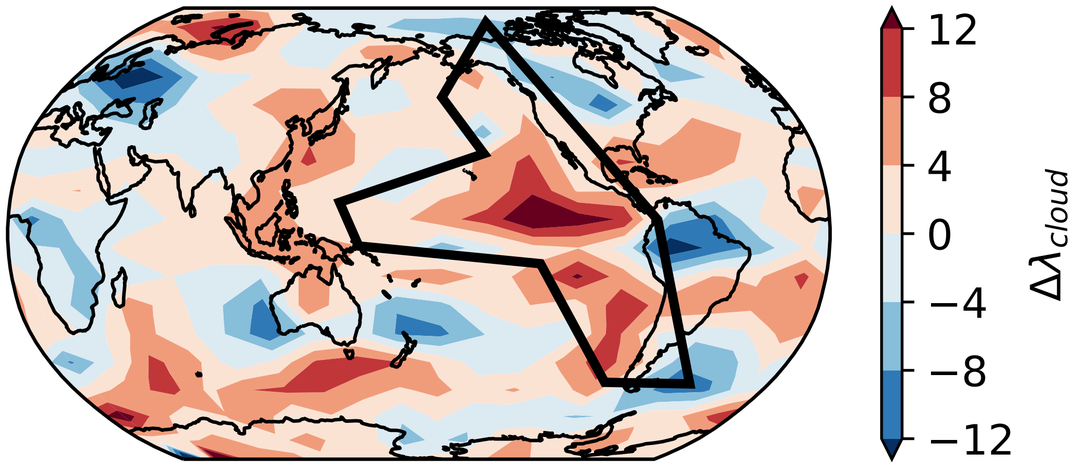
CERES+ERA5



best model



CERES+ERA5



conclusions

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- overall, the cloud feedback derived from CERES agrees well with cloud feedback in CMIP6 control runs

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conclusions

- overall, the cloud feedback derived from CERES agrees well with cloud feedback in CMIP6 control runs
- we find a large “pattern effect” in the cloud feedback (~1 W/m^2/K) when we split the CERES data into two parts
- it is associated with different amounts of E. Pacific warming
- CMIP6 models reproduce the observations well